The Engineer

DECEMBER 11, 1953 28, ESSEX ST., STRAND, LONDON, W.C.2 TWO SHILLINGS

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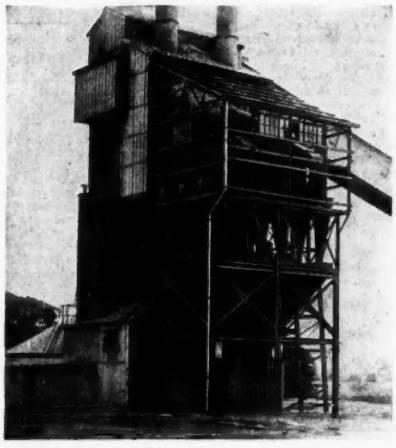

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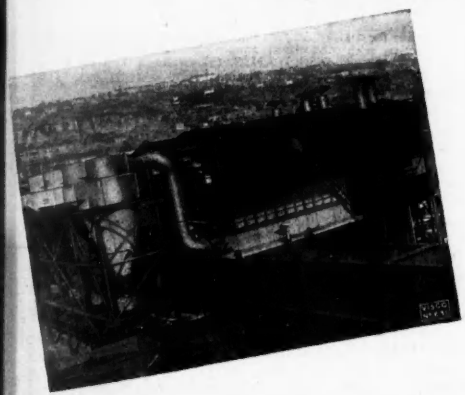

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THE ENGINEER

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DECEMBER 11, 1953

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PRINCIPAL CONTENTS

(Complete contents on page 774)

Shortage of Naval Engineer Officers 774

East Coast Sea Defence Works 758

Locomotive Valve Gears 762
(E. C. POULTNEY)

Smithfield Show and Agricultural Machinery Exhibition—No. II 781

Creep Properties of Steels 768

Iron and Steel Institute—No. II 777

Greek Line Steamship "Olympia"—No. II ... 771

Cornish Engines 774

NOTICE TO READERS

All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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WORDING OF ADVERTISEMENTS: Approximately the first 25 letters of each advertisement are set in heavy type. Advertisers are therefore advised to begin their advertisements with the words they want emphasized.

Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

INDEX TO ADVERTISERS—PAGE 139

PUBLIC APPOINTMENTS

UNIVERSITY OF DURHAM

CHAIR OF CHEMICAL ENGINEERING

Applications are invited for the newly created CHAIR OF CHEMICAL ENGINEERING, tenable at King's College, Newcastle upon Tyne. The person appointed will take over the existing facilities for teaching and research in chemical engineering at King's College. He will be required to take up appointment not later than 1st October, 1954. Salary not less than £1750 per annum with F.S.S.U. and family allowances. Applications (12 copies), containing the names of three referees, should be lodged with the undersigned, from whom further particulars may be obtained, not later than 18th January, 1954. (Applicants from outside the British Isles may send one copy only.)

E. M. BETTENSON,
Registrar.

University Office,
46, North Bailey,
Durham. E6296

SURREY EDUCATION COMMITTEE

BROOKLANDS COUNTY TECHNICAL COLLEGE,
HEATH ROAD, WEYBRIDGE

FULL-TIME POSTS

Applications are invited for the following full-time posts :—

1. LECTURER IN MECHANICAL ENGINEERING.

Applicants should be Graduates of a British University and/or Corporate Members of the Institution of Mechanical Engineers and have had adequate industrial and teaching experience. Candidates should be prepared to teach up to Higher National Certificate standard. Preference will be given to candidates who can offer the subjects of strength of materials, theory of machines and mechanics of fluids at the higher standard.

2. ASSISTANT in MECHANICAL ENGINEERING (Grade A or B).

Requirements as for Lecturer's post. Salary grade dependent on qualifications and experience.

3. ASSISTANT in PRODUCTION ENGINEERING (Grade A or B).

The work will be concerned with Ordinary National Certificate Courses in Production Engineering and the City and Guilds of London Institute Trades Courses requirements in allied subjects. It is intended eventually to develop the work to Higher National Certificate standard. Applicants should possess sound technological qualifications and good industrial experience. Teaching experience is desirable. Preference will be given to those with a knowledge of machine tools, jigs and fixtures, metrology, heat treatment and welding practice. Salary grade dependent on qualifications and experience.

4. ASSISTANT in ELECTRICAL ENGINEERING (Grade A or B).

Applicants should possess a Degree in Electrical Engineering or its equivalent and have had adequate, industrial and teaching experience. Corporate Membership of the Institution of Electrical Engineers will be an added recommendation.

The successful candidate will be required to teach to the Ordinary Certificate standard at present besides subjects pertaining to allied trades. He should be prepared to teach up to Higher National Certificate standard. Salary grade dependent on qualifications and experience.

Salary scales for men : Lecturer, £940 by £25 to £1040 p.a.; Assistant "B," £490 by £25 to £765 ; Assistant "A," £415 by £18 to £670 p.a. Assistants may receive additions to scale for approved qualifications and study. Commencing salary dependent upon previous teaching and other approved experience. Duties for all posts will include some evening teaching.

Application forms obtainable on receipt of a stamped (2½d.) addressed envelope from the Principal, to whom they should be returned by 31st December, 1953. E6379

SURREY EDUCATION COMMITTEE

WIMBLEDON TECHNICAL COLLEGE, GLADSTONE ROAD, S.W.19

HEAD OF THE MECHANICAL ENGINEERING DEPARTMENT

Applications are invited for the post of HEAD of the MECHANICAL ENGINEERING DEPARTMENT to commence duties as soon as possible.

Candidates should have had good industrial and teaching experience. Salary, Burnham Scale for Heads of Departments, Grade II (men), £1000 by £25 to £1150 p.a., plus £40 p.a. special addition, plus London allowance. The present grade of the department is II. The question of an increase in salary beyond this rate will be considered under the new 1954 Burnham Award. No undertaking can, however, be given at this stage that any increase will in fact be granted.

Particulars of the post and application form may be obtained from the Principal, to whom the application should be returned not later than 1st January, 1954. E6377

PORT OF LONDON AUTHORITY

SECOND-CLASS DRAUGHTSMEN

The Port of London Authority invite applications for positions as SECOND-CLASS DRAUGHTSMEN at the Authority's Head Office and the Royal Victoria Dock, Custom House, E.16, to detail reinforced concrete, steel and timber structures with or without supervision. Maritime works experience and ability to make site surveys would be an advantage. Commencing salary, according to qualifications and experience, within the scale (inclusive of pay supplement) £552 per annum, rising by annual increments to £596 per annum.

Application forms may be obtained from the Establishment Officer, Port of London Authority, Trinity Square, London, E.C.3. E6402

PUBLIC APPOINTMENTS

NORTHAMPTONSHIRE EDUCATION COMMITTEE

WELLINGBOROUGH TECHNICAL COLLEGE

(Principal : S. A. J. PARSONS, B.Sc. (Econ.), M.I.Mech.E.)

FULL-TIME ASSISTANT MASTER

Required as soon as possible, a full-time ASSISTANT MASTER, to take classes for the motor vehicle mechanics and similar courses. The College is well equipped for all the necessary practical work. Previous teaching and industrial experience is desirable.

Salary in accordance with Grade A of the Burnham Scale of Salaries for Teachers.

Forms of application and particulars may be obtained from the undersigned, to whom completed applications should be returned by 28th December, 1953.

Candidates desiring the return of their testimonials should forward a stamped addressed envelope.

G. E. CHURCHILL,
Chief Education Officer.

County Education Offices,
Northampton,
December, 1953. E6378

ROYAL AIRCRAFT ESTABLISHMENT TECHNICAL COLLEGE

FARNBOROUGH, HANTS

DEMONSTRATORS

Farnborough, Hants, Royal Aircraft Establishment Technical College (Selective, Day), requires DEMONSTRATORS in (I) Electrical Engineering and Physics, (II) Mechanical Engineering. Candidates should hold University Degree or equivalent, preferably with some industrial experience, and be able to assist in organisation, preparation and control of work in laboratories under guidance of Senior Lecturers. A little teaching may be involved. Facilities for research and further study may be available. Salary on Burnham Scale £375 by £18 to £630, plus £40 special addition and usual allowances, resulting in possible maximum starting salary of approximately £500, plus increments for experience, for fully qualified man. Post subject to Teachers' Superannuation Acts.—Details and forms from Principal, to whom completed forms must be returned within fourteen days of this notice. E6364

SOUTH DEVON WATER BOARD

AVON DAM

RESIDENT ENGINEER

Applications are invited for the appointment of RESIDENT ENGINEER to supervise, under the consulting engineers, the construction of an impounding reservoir on the River Avon, near South Brent, Devon. The works comprise a concrete gravity dam with a length of about 860ft and a maximum height of about 100ft above river level, together with valve tower, spillway, gauging bay and ancillary works. It is expected that work will commence in April, 1954, and will take at least three years to complete.

Applicants must be Corporate Members of the Institution of Civil Engineers and have had previous experience in this class of work.

The salary will be £1500 per annum, rising by annual increments of £100 to a maximum of £1800 per annum. The Resident Engineer will also receive a living allowance of £200 per annum and an allowance for a car in accordance with the National Joint Council Scale. The appointment is to be terminable by three months' notice on either side.

The successful applicant is expected to make his own arrangements for housing accommodation, which should be as close to the works as is reasonably practicable.

Applications, giving full details of age, qualifications and experience, together with the names and addresses of at least two persons to whom reference might be made, are to be sent to the Board's Consulting Engineers, Messrs. Lemon and Blizard, 59, Tufton Street, Westminster, London, S.W.1, not later than 1st January, 1954.

F. BROWN,
Clerk of the Board.

Churston House,
Kingsbridge, Devon,
26th November, 1953. E6279

INDIA

DEMONSTRATOR INSTRUCTOR

Wanted urgently in India, DEMONSTRATOR INSTRUCTOR for training of apprentices in Technical School and Workshops at Chittaranjan Locomotive Works, West Bengal. Should be able to give practical demonstration in the School Workshop and to lecture clearly on practical elementary engineering in general, correct use of hand tools, and understanding of all machinery processes. Applicants should have some or all of the following :—(a) Apprenticeship and practical experience of mechanical engineering ; (b) equivalent of Higher National Certificate ; (c) experience in teaching mechanical engineering and ability to compile curriculum for their training, and (d) locomotive building or repair experience, although this is not essential. Salary : married, £900 p.a. (taxable), plus tax-free allowance of £1025 p.a., with additional allowances for children ; single, £900 p.a. (taxable), plus tax-free allowance of £635 p.a. Free furnished accommodation, free medical expenses, free first-class return passages ; kit allowance. Contract for two years with possible extension.—Application forms from M.L. and N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting D389/53A. E6409

PUBLIC APPOINTMENTS

CIVIL SERVICE COMMISSION

SENIOR SCIENTIFIC OFFICERS, SCIENTIFIC OFFICERS, PATENT EXAMINER AND PATENT OFFICER CLASSES

The Civil Service Commissioners invite applications for permanent and pensionable appointments to be filled by frequent competitive interviews. The Scientific Posts are in various Government Departments and cover a wide range of scientific research and development in most of the major fields of fundamental and applied science. In biological subjects the number of vacancies is small : individual vacancies exist at present for candidates who have specialised in palaeobotany, invertebrate fossils and foraminifera. The Patent Posts are in the Patent Office (Board of Trade), Admiralty and Ministry of Supply.

Candidates must have obtained a University Degree with First or Second-Class Honours in an appropriate scientific subject (including engineering), or in Mathematics, or an equivalent qualification, or for Scientific Posts, possess high professional attainments. Candidates for Senior Scientific Officer Posts must, in addition, have had at least three years' post-graduate or other approved experience.

Age limits : Senior Scientific Officers, between 26 and 31, but specially suitable candidates under 26 may be admitted. For Scientific Officers and Patent Classes, between 21 and 28 during 1953 (up to 31 for permanent members of the Experimental Officer Class competing as Scientific Officers). Inclusive London salary scales : Senior Scientific Officers, (men) £917–£1075, (women) £786–£949 ; Scientific Officers, (men) £440–£812, (women) £440–£707 ; Patent Examiner and Patent Officer Classes, (men) £440–£760, (women) £440–£576. Women's rates for, Patent Classes under review. Somewhat lower rates in the Provinces.

Further particulars from the Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.53/53 for Senior Scientific Officers, and S.52/53, S128/53, for the other posts. Completed application forms to be returned on or before 31st December, 1953. E6401

SOUTH ESSEX WATERWORKS COMPANY

APPOINTMENT OF DEPUTY CHIEF ENGINEER

Applications are invited for the above appointment at a commencing salary of £1600 per annum.

Applicants should possess a sound knowledge of waterworks practice and the operation of works of some magnitude, also administrative ability. Experience of abstraction, storage and treatment of river water would be of value.

Candidates should be Corporate Members of the Institution of Civil Engineers and not more than 45 years of age. The appointment (which will be terminable by three months' notice on either side) will be subject to admission to the company's contributory superannuation scheme (details of which are available) and a satisfactory medical report.

Applications, endorsed "Deputy Chief Engineer," stating age, qualifications and experience, accompanied by copies of three recent testimonials and the names and addresses of three persons to whom reference may be made, should be sent to the undersigned not later than 31st December, 1953.

HUGH G. RAMSAY, M.I.C.E.,
Chief Engineer.

342, South Street,
Romford, Essex. E6293

SECOND ADVERTISEMENT

NATIONAL COAL BOARD

WEST MIDLANDS DIVISION

AREA CIVIL ENGINEER

Applications are invited for the post of AREA CIVIL ENGINEER in the No. 1 (North Staffordshire) Area of the West Midlands Division.

The engineer appointed will be responsible for all surface civil engineering work in connection with major reconstructions.

Applicants must be Corporate Members of the Institution of Civil Engineers and have had experience in the design of heavy foundations for machinery and structures, drawing up specifications and obtaining tenders and administering contracts.

The main civil works comprise heapsteads, coal preparation plants, winding engine houses, workshops, stores, offices, &c., layout of railway sidings and drainage arrangements. A good salary will be paid, depending on applicant's training and experience.

Applications in writing should be addressed to the Divisional Establishment Officer, National Coal Board, West Midlands Division, Himley Hall, Dudley, Worcs.

Previous applicants need not re-apply. E6351

MINISTRY OF SUPPLY

ENGINEER OR TECHNICIAN

Ministry of Supply requires ENGINEER or TECHNICIAN in London for planning, progressing production of electric cables and wires mainly for aircraft H.F. operation. Qualifications : British of British parents ; recognised engineering apprenticeship ; at least H.N.C. or equivalent desirable, A.M.I.Mech.E. or E.E. preferable. Good general knowledge cable making materials and methods ; ability assess production capacity. Salary : within £733–£891 (H.N.C. level) or £780 (less below age 30) —£1000 (full professional qualifications). Not established but opportunities to compete for establishment may arise.—Application forms from M.L. and N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting D389/53A. E6383

PUBLIC APPOINTMENTS

ADMIRALTY

ROYAL NAVAL SCIENTIFIC SERVICE

ENGINEERS AND PHYSICISTS

ENGINEERS and PHYSICISTS (particularly with electronics) required for appointments as Experimental Officer and Assistant Experimental Officer grades in Experimental Establishments in London, Portsmouth, Weymouth and Gloucestershire areas and Scotland. Candidates, British subjects, must possess one of the following qualifications : University Degree in Science, Engineering or Maths., Graduate Membership of appropriate professional institute, Higher National Certificate, Final Certificate of five-year grouped course in relevant subjects at City and Guilds of London Institute or comparable institution, Higher School Certificate, General Certificate of Education, Scottish Leaving Certificate, Scottish Universities Preliminary Examination, Northern Ireland Senior Certificate (a) in appropriate subjects and at appropriate levels, London salary inclusive of pay addition (men) : E.Os., £681–£838 ; A.E.Os. (according to age) £274–£607. All appointments unestablished, but with some opportunities to compete for established posts.—Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting A247/52/A. E6339

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

MECHANICAL ENGINEERING RESEARCH LABORATORY

EXPERIMENTAL OFFICER

Department of Scientific and Industrial Research require EXPERIMENTAL OFFICER (unestablished) at the Mechanical Engineering Research Laboratory, East Kilbride, near Glasgow, for work on plastic deformation and cutting of metals. Passed Degree or Higher National Certificate in Engineering or Physics, with experience in design of experimental equipment and of instruments for measuring metal flow. Experience in the mechanical testing of metals desirable and an interest in metallurgy or electronics an advantage. Minimum age 26 ; prospects of establishment if under 31. Inclusive annual remuneration (45½-hour week) £669–£823 men, rather less for women. Favourable housing prospects at East Kilbride for married staff.—Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting Ref. C631/53A. Closing date 2nd January, 1954. E6365

INDIA

RATE FIXERS AND MACHINE TOOL DEMONSTRATORS

Wanted urgently in India, for modern locomotive works at Chittaranjan, West Bengal, experienced RATE FIXERS for (a) boiler shop, (b) fitting and erecting shop, (c) foundry, and (d) smithy and forge, and MACHINE TOOL DEMONSTRATORS for (a) heavy section, (b) light machine shop, and (c) grinding machines. Applicants must have wide practical knowledge of their trades. Locomotive experience preferable, but not essential. Salary : married, £750 p.a. (taxable), plus tax-free allowance of £850 p.a., with additional allowances for children ; single, £750 p.a. (taxable), plus tax-free allowance of £500 p.a. Free furnished accommodation, free medical expenses, free first-class return passages ; kit allowance. Contract for two years with possible extension.—Further details, with application forms, obtainable from Commonwealth Relations Office, Room M.S. 41, Downing Street, London, S.W.1. E6410

BRISTOL AVON RIVER BOARD

ENGINEERING ASSISTANTS

Applications are invited for the permanent superannuated appointment of TWO ENGINEERING ASSISTANTS, (a) Grade X and (b) Grade VIII, under the National Joint Council for Local Authorities, &c., whose conditions, travelling allowances and medical examination requirements will apply. Candidates must be Associate Members of the Institution of Civil Engineers and have had extensive experience in design and construction of hydraulic works. Full details with three testimonials and endorsed "Assistant Engineer," (a) or (b), should be received by the undersigned not later than 31st December, 1953.

G. M. YATES,
Clerk to the Board.

18, Bennett Street, Bath,
3rd December, 1953. E6374

NATIONAL PHYSICAL LABORATORY

ASSISTANT EXPERIMENTAL OFFICERS

National Physical Laboratory, Teddington, Middlesex, require 12 ASSISTANT EXPERIMENTAL OFFICERS, for work in physics, mathematics and engineering. Age over 18. Qualifications : G.C.E. in appropriate subjects, including two scientific or mathematical subjects, at advanced level. Candidates, over 22, will normally be expected to have a pass Degree, H.N.C., or higher qualification. Posts unestablished, but prospects of establishment through the Civil Service Commission for candidates under 25. Inclusive annual remuneration for a 45½-hour week in the range £282–£626 (men), £282–£526 (women).—Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting A316/53A. Closing date 2nd January, 1954. E6366

THE ENGINEER

DECEMBER 11, 1953

Shortage of Mathematics and Science Teachers

A REPORT which has been submitted to the Minister of Education by the National Advisory Council on the Training and Supply of Teachers states that the shortage of graduate teachers of mathematics and science constitutes a national problem. The council says that unless enough men and women with suitable abilities and qualifications come forward, to teach in schools there must be serious long-term effects both on the general quality of education of the nation and on the future supply of scientists and technologists. After surveying the existing position in the schools, the council recommends in its report that the Ministry should invite local education authorities to review the distribution of graduate teachers of science and mathematics in their areas, and to ensure that all teachers qualified to teach mathematics and science are in fact doing so and that they are fully employed to the best advantage. The report also suggests a more widespread employment of laboratory assistants in schools, commenting that greater assistance of this kind should result in an improvement in the quality of teaching and might also assist in the recruitment of graduate teachers. The report shows that industry and the universities are the two principal competitors of the schools for the services of mathematics and science graduates. The conclusion reached is that the demand from these two competing occupations is strong and is likely to continue. The report says that an increase in the size of the undergraduate population, particularly women, might assist in due course the recruitment of graduate school teachers, but more immediately the schools might benefit if there were a temporary slackening of demand by industry. The effect of such measures, however, is not likely to be great enough or quick enough to enable the schools to solve their problems in the next seven years, and for this period the schools must be enabled to compete more effectively in the existing limited market. The council says that it has not investigated the claim that, while the starting level of pay for graduates in the schools is at least equivalent to that outside, the prospects of a successful graduate are markedly better in industry than in school teaching. Nevertheless, the council is satisfied that financial prospects are a main factor in the situation. Furthermore, the council believes that the total number of mathematics and science teachers would be increased if the recent trend for more teachers to stay on beyond the normal retiring age were to continue.

Engineers' Guild

THE annual general meeting of the Engineers' Guild was held in London on Wednesday evening. The Guild was founded in 1938 and the report of the council, which was presented at last Wednesday's meeting, records the steady progress of its home and overseas branches. Among the activities of the Guild which are mentioned in the report is the appointment of an *ad hoc* committee to advise the council on ways and means of helping older engineers. One result of this committee's work has been a meeting with the Professional Engineers Appointments Bureau, at which it was agreed that the Guild could do valuable work by fostering a more sympathetic attitude in employers and seeking to explain to them how they might make use of the special abilities of older engineers, not necessarily by placing them in recognised vacancies, but by perceiving a "void" which they might fill. In some introductory remarks at the meeting the president of the Guild, Mr. H. Nimmo, said that the membership now numbered nearly 3600 and that during 1953 the rate of growth had been somewhat higher than in the preceding three years. It was disappointing, however, that the membership curve was not so steep as was hoped. The president went on to refer to the membership of the three senior engineering institutions as the "potential market" for recruitment to the Guild. He said that if allowance was made for engineers who might belong to more than one of those institutions he thought the total membership should be approximately 70,000. A realistic goal for the Guild to aim at, he suggested, would be 50 per cent of that figure, or, say, 35,000. At present, Mr. Nimmo continued, the Guild's membership was just over one-tenth of that number. He therefore made a special appeal for all possible assistance in the achievement of the aim which he had outlined, for the Guild provided the means and the opportunity for marshalling the strength of the engineering profession.

Report of the Committee on Air Pollution

ON Thursday of last week, the Committee on Air Pollution issued an interim report. This committee, it will be recalled, was set up last July by the Minister of Housing and Local Government, the Minister of Fuel and Power, and the Secretary of State for Scotland. Sir Hugh Beaver, M.I.C.E., is the chairman of the committee, and its terms of reference are: "to examine the nature, causes and effects of air pollution and the efficacy of present preventive measures; to consider what further preventive measures are practicable; and to make recommendations." The first part of the interim report surveys the problem of air pollution in this country and puts forward some general recommendations, including the use of smokeless fuel by industrial and domestic users. One recommendation is that the Meteorological Office should issue warnings by appropriate channels, and in particular by the B.B.C., of areas of normally high pollution in which serious fog is expected to persist for at least twenty-four hours. The second part of the report presents a more detailed technical study of the problem of air pollution. The problem of reducing pollution, the report says, and of creating real smokeless zones, is largely that of the practical means. Short of stopping people from lighting fires and bringing industry to a standstill, prevention can be enforced only if there is the necessary technical knowledge, the will and the means of applying it, and the appropriate fuel. The causes and remedies of pollution by smoke are known and, as the report emphasises, the problem is one of practicability and economics and of the education of the whole community. The committee takes the view that complete cure of both solid and gaseous pollution, if indeed it be ever attainable, is bound to take many years, but means of averting at least the worst evils of air pollution by smoke and grit are within practicable reach. It is simply a question, the report comments, of balancing the cost and inconvenience of enforcing a more efficient and scientific use of our fuels against all the advantages in health, convenience and economy to be obtained from a clear atmosphere.

Reinforced Concrete Association

ON Tuesday, December 1st, the Reinforced Concrete Association celebrated its twenty-first anniversary by holding a dinner and dance at the Dorchester Hotel. During the course of the speeches which followed the dinner, the toast of the Association was proposed by Mr. A. J. Lennox-Boyd, Minister of Transport and Civil Aviation, and Mr. H. G. Cousins, president of the Reinforced Concrete Association, responded. The Association's vice-president, Mr. C. H. S. Howkins, proposed "the guests," and speeches were made in reply to that toast by Mr. C. H. Aslin, vice-president of the Royal Institute of British Architects, and Sir Richard Coppock, of the National Federation of Building Trade Operatives. The history and progress of the Reinforced Concrete Association during its twenty-one years were outlined by the president in his speech. Its membership, he noted, included both companies and individuals—those who manufactured or supplied the various ingredients of reinforced concrete, the things into which the concrete was placed, and the plant, machinery and tools with which it was transported and consolidated. It also included contractors, makers of precast concrete products, those concerned in design, research and education, a leaven of consulting engineers and a dash of architects. It did not concern itself with matters lying within the domain of one particular branch, he said, but existed as a forum for the exchange of knowledge and of ideas, to promote, encourage and improve the art, science and practice of reinforced concrete design and construction. Much of the Association's pre-war work, Mr. Cousins noted, was devoted to the task of freeing the industry from the restrictive legislation which, he said, had previously so hampered its growth; it still assisted in the drafting of British Standard Specifications and Codes of Practice. The growth of the concrete industry had been steady and continuous, he went on, and a fair indication of the use of concrete was given by the consumption of reinforcement, which in 1952 was 50 per cent above that of the peak period of 1938, with the considerable volume of work in prestressed concrete in addition. Membership of the Association was not idly conferred, Mr. Cousins contended, but was limited to those who by their qualifications and standing might be expected to uphold a standard of excellence in reinforced concrete design and construction. Members should see that reinforced concrete was used wisely and well for the benefit of mankind, he concluded.

British Steel Founders' Association

ON Wednesday, December 2nd, the British Steel Founders' Association held a dinner at Claridge's Hotel, London. Mr. Walter Elliot, M.P., proposed the toast of "The Association." He remarked that the production of member firms of the Association last year amounted to a turnover of £25,000,000. It was not only hard work that made that output possible. The skill of the workers, the intelligence of those who directed them, the inventiveness of the British people, and that tolerance which enabled teamwork to go on were in some ways the envy of the world. The sending of productivity teams to the United States had been the right thing to do. We should learn from anyone who could teach us something. But in Britain we had attained a reputation for working together that was even more valuable than skill. Mr. F. N. Lloyd, vice-chairman of the Association, said in reply that it was the present task of the Association to do everything possible to increase exports, and the Government was entitled to the full support of the industry. That day their industries were largely idle because the workers were demanding a 15 per cent increase in money for no increase in work. That increase could easily be given if there were a corresponding increase in work. Indeed, there was an easy 30 per cent increase in output to be got by the right kind of co-operation between management and labour. The toast of "Her Majesty's Forces" was proposed by Mr. T. H. Summerson, chairman of the Association. In reply, Admiral of the Fleet Lord Fraser remarked that there was no doubt that the quality, ingenuity and craftsmanship of those who worked in British industry was as high as ever, even if, perhaps, they might work a little harder! The toast of "The Guests" was proposed by Mr. G. M. Menzies, member of council, and Mr. H. Yates responded.

East Coast Sea Defence Works

No. II—(*Continued from page 746, December 4th*)

A vast programme of constructional work has been in progress in East Coast areas to make good damage caused by the storm and tidal surge on the night of January 31st last. This work is being carried out principally by a number of River Boards, and much of it has now been completed or reached an advanced stage. The description herewith is of the new works along the shores of the Wash, and the Norfolk aud Suffolk coast.

WE mentioned last week a small breach in the Lincolnshire River Board's area south of Skegness near Gibraltar Point. No other damage was experienced until the Welland River Board's coastline is reached, where there were two breaches north of the Welland estuary (Fosdyke Wash) and one major breach, and some smaller ones, in the reclamation areas to the south of the mouth of the Welland. Further along the coast of the Wash there was another breach near the mouth of the Nene. Heightening of the banks of the Welland estuary, the reclamation banks, and along the coast near the latter breach, has been completed.

Shortly after the flooding, seventeen contractors had plant on the various sites of these sea banks, in response to an appeal for immediate assistance, and altogether some forty excavators and bulldozers were at work. 14 miles of banks have been repaired and heightened along the Welland estuary and from there to the Nene. Generally, the top level is between 23 and 21·5 O.D.N., the top width 10ft and the seaward slope 5 : 1 ; previously, these figures were generally 18 to 19 O.D., 6ft and 3½ : 1, respectively. The banks are turfed for wave protection. The secondary banks have been repaired to form a continuous second line up to +16 O.D. The high tide level actually experienced in this area on January 31st was about +19 O.D., still water level. The predicted level was +11 O.D. and the maximum predicted spring tide level is about +14·3 O.D.

The two reclamation areas to the south of the Welland are each about 750 acres in extent, and are enclosed by banks totalling 6½ miles in length. The southerly of the two was flooded as a result of the major breach, and work has recently been completed in restoring the banks at this point ; elsewhere, the 6½ miles of banks have been heightened to 23·0 O.D.N. and strengthened to the same standard as the banks of the Welland estuary. The repair of the major breach in the southern reclamation area was no easy task. Excavators had to be brought along the bank and across the marsh on timber mats for long distances, and conditions generally were arduous. Three creeks draining into the breach were first sealed off. The wall across the breach was 350 yards long and built of silt. The entire face of this was covered with a double layer of sandbags. Owing to the wet nature of the soil the height of the bank was increased gradually, keeping it above the levels of the rising spring tides. A borrow area was left close to the wall for future use, should there again be damage at this point.

These various works of the Welland River Board have been carried out under the direction of its chief engineer, Mr. E. G. Taverner, at a cost of about £165,000. Altogether about 1,000,000 cubic yards of material was excavated for the work, this figure including the double-handling necessary on some of the embankments. The main contractor was George Wimpey and Co., Ltd.

The next stretch of coastline where extensive reconstruction has been in progress extends from Wolferton to Hunstanton, a distance of 8 miles along the Norfolk coast, which is the responsibility of the Great Ouse River Board, as far as sea defence work is concerned. Near the mouth of the Great Ouse the accreting foreshore does not permit much wave action against the sea defences, and there was little damage. But such was not the case along the length mentioned above. Here the land is generally low-lying and there is a sea bank a few hundred yards back from the foreshore, which, up to the beginning of this year was considered as a second line of defence from the sea. There are extensive shingle deposits in front of the embankment, which end in a ridge of shingle—the former first line—on the foreshore. Behind the shingle ridge at Snettisham much of the deposit has been quarried for concrete aggregate, and access to the ridge is rather limited. On January 31st both the shingle ridge and the embankment were overtopped and there were serious casualties in the beach bungalows built along the ridge, some sixty people being killed. 4300 acres of land were flooded, there were three large breaches on the shingle bank and forty breaches from a few yards to 100 yards in extent, in the embankment. The still water height was estimated to be about 8ft above that predicted, or, say, +18·5 O.D.

The works carried out this summer consist mainly of repairing and heightening the embankment, although in the early stages, the damaged shingle ridge was reformed in many places by bulldozers and other plant. The bank has been built up to a level of +22·5 O.D. (previously it was +16 O.D.) with a top width of 6ft and a seaward slope of 2 : 1, giving a base width of about 45ft. Borrow pits behind the bank were excavated by scrapers (a score of such machines were at work) which emplaced the material, and only the final trimming was done by bulldozers and draglines. The reconstruction was completed in twelve weeks, about 350,000 cubic yards of excavation being moved and built into the bank. A length of about ¾ mile is now being faced with a cast-in-situ reinforced concrete slab 7in thick, as a protection from wave action. "V"-grooves are formed in the slab at about 3ft intervals, to encourage cracking along the grooves should the embankment settle appreciably. Dwarf cross walls are built down the slope at intervals, to break up the travel of a wave along the slope. The bank reconstruction necessitated raising the road level by about 6ft at three road crossings and the building of considerable approach ramps, and the construction of four concrete culverts. A typical example of the latter is shown in Fig. 9.

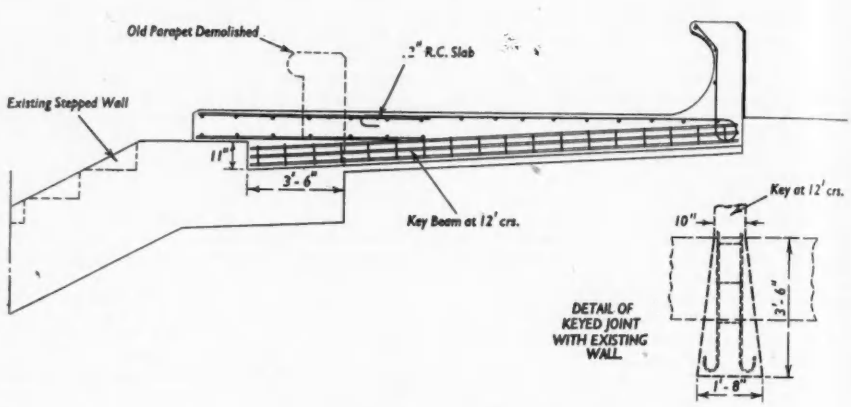


Fig. 10—Reconstruction of Sea Wall Near Hunstanton

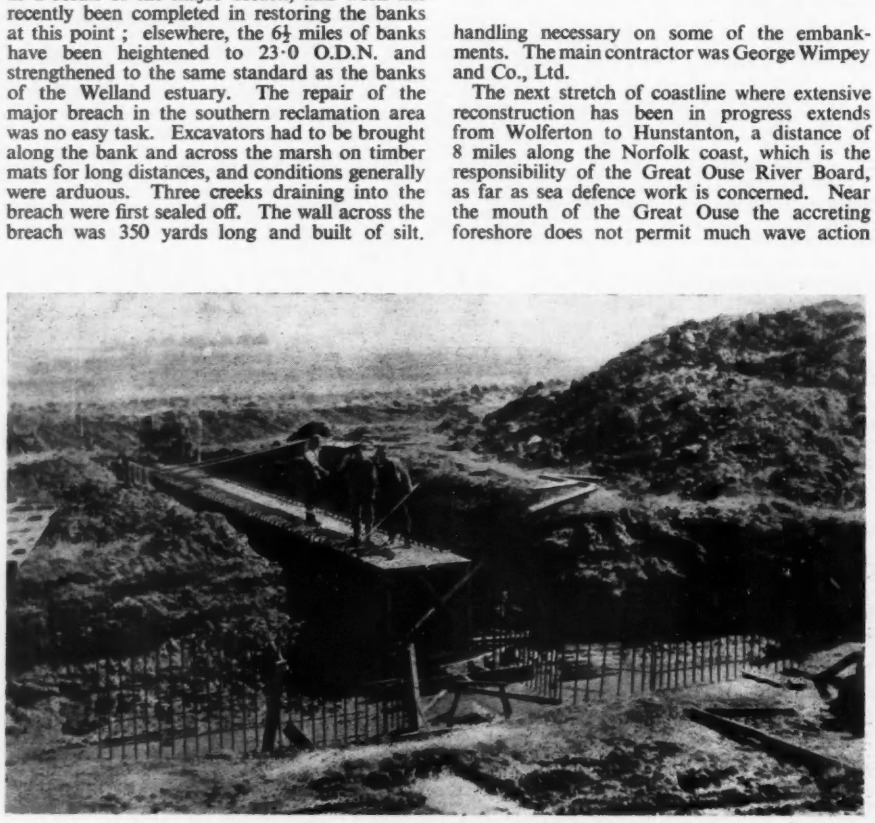
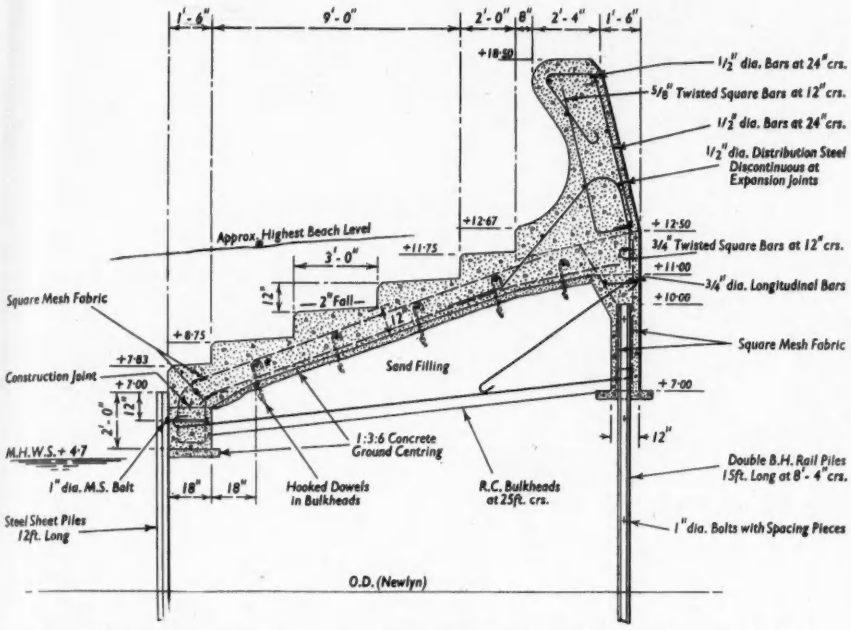


Fig. 9—Construction of Culvert Through Sea Embankment

Near Hunstanton, concrete sea defences have been reconstructed for a length of about a mile. An entirely new wall is under construction for a length of some 300 yards. It is a stepped wall, built on a chalk embankment, with a steel-sheet-piled cut-off 12ft long at the toe. There is to be a promenade 35ft wide at the top of the wall and a wave wall is to be built at the back of the promenade, the top of the stepwork, the promenade and the wave wall all being reinforced together. The level of the coping of the promenade is 17·75 O.D. and the top of the wave wall is at 22·0 O.D.

Reinstatement of the existing concrete walls involved placing fill behind them, principally chalk from a neighbouring quarry. The wave wall of a sloping sea wall extending for 900 yards



in dowelled expansion joints at 25ft centres are carried through parapet and stepped walls. Top surface of bulkhead is finished smooth and painted with bitumen over one half at expansion joints. The top of the rail pile midway between bulkheads is braced to the toe wall with a single B.H. rail.

Fig. 11—Stepped Wall at Sea Palling

was renewed where necessary ; the earth bank runs behind this length of wall. Then there is a stepped wall, which had to be heightened, as the earth bank joins the line of the sea front between the two types of wall. The method of raising the stepped wall, incorporating a promenade, is shown in Fig. 10. The old parapet of the wall has been removed and replaced by the promenade, with the wave wall at the back of it. The interest of this work lies in the method of reinforcing the wave wall by connecting it with tie beams to the old step wall. Wedges are cut in the old wall and reinforced concrete beams built across, under the promenade, to link with the wave wall ; this construction is clearly shown in the drawing.

The various works between Wolferton and Hunstanton have been carried out under the direction of the Great Ouse River Board, whose chief engineer is Mr. W. E. Doran. The contractors for the 300ft length of new reinforced concrete wall is J. L. Kier and Co., Ltd., and the Board is acting as consultant to the New Hunstanton U.D.C. for this work. For the various other works, the contractor is the Ormac Construction Company, Ltd.

Tidal levels, rather than flood levels, are predominant for about 21 miles of the Great Ouse, and on the tidal river there were five large breaches on the left bank and three very large breaches on the right bank. The breaches on the left bank, which totalled about 580ft in length and varied in depth from 10ft to 16ft below bank top, were all closed before the morning tide following the surge (February 1st). There were also several breaches on the left bank of the river at King's Lynn and two large breaches on the right bank of the River Nar. All of these breaches were finally closed within about a week of their occurrence. Altogether, some 6200 acres of land were flooded in the tidal river area.

Apart from the very large amount of emergency work which was done in reinstating the tidal river banks, a sum of about £15,000 has been spent in raising the banks. This bank raising is of an interim character, as provision has been made in the major flood protection scheme for the Great Ouse, for the raising and improvement of these banks. It is hoped that a start may be made on the scheme next year.

The level of the quays and riverside structures in King's Lynn north of the River Nar is such that a certain amount of spill-over occurs at very high spring tides. There are no flood embankments on this length of river and considerable flooding of the built-up area took place by spill in this way. South of the River Nar, however, most disastrous flooding occurred in a low-lying area. So sudden was the rise of water level here that a number of people were trapped in their houses and fifteen persons were drowned. There was no failure of the river embankments.

On the opposite side of the river at West Lynn, considerable flooding also occurred. The River Board has prepared a scheme for the protection of the town from tidal surges. While it is not possible to give complete protection from extremely high surges to the area north of the River Nar on account of the impossibility of raising the coping level of the dock and on account of the existence of railway lines, quays

Fig. 14—Construction of Stepped Wall

and wharves, nevertheless, some improvement can be made, while with regard to the area south of the River Nar and the West Lynn area, protection has been provided against a level 2ft above the level of the recent surge. Road access and railway lines have provided many difficult problems in this area and much use has had to be made of concrete surge walls where space has been insufficient to allow of the building of flood banks.

The expenditure on these various works of the Great Ouse River Board amounted, during the emergency period, to about £170,000, and the expenditure on improvement schemes, including work being carried out by the Norfolk Estuary Company for the raising of their sea banks and the work being carried out by the New Hunstanton Urban District Council, amounts to approximately £300,000.

The Norfolk and Suffolk Coast

The coastline corresponding to the various river catchments administered by the East Suffolk

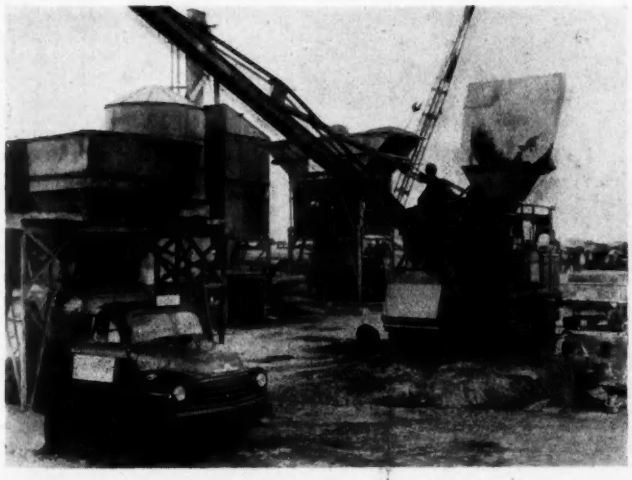


Fig. 12—Concrete Batching and Mixing Plant at Sea Palling

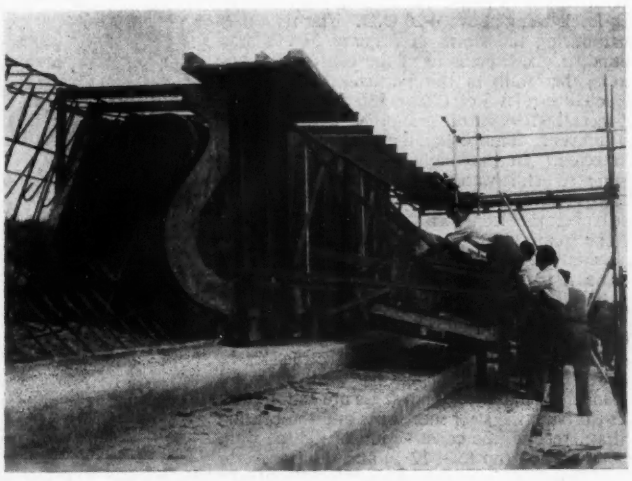


Fig. 13—Shuttering Unit for Bull-nosed Wave Wall

and Norfolk River Board extends from Hunstanton to Felixstowe, but there are various local authorities along that coast which are responsible for the sea defences in their own areas. The coast line for which the Board itself is responsible is 120 miles in length, with about 300 miles of river estuaries in addition. Reconstruction work has been very varied to suit the differing conditions encountered along this extensive length of coast line, where some 3000 breaches were caused by the storm damage of January 31st.

As an example of the work carried out on this part of the coast, we give below some details of the new defences between Eccles and Winterton, just north of Yarmouth. Here again, the land is low-lying and there are sand dunes, of varying extent, all along the coastline. Where the dunes are more meagre, or were severely damaged, new concrete sea walls are being built ; on other lengths the new works are less substantial. The 6½ miles between Eccles and Winterton includes the village of Sea Palling, which suffered very severe damage last January, and also the old breach of 1938, when the sea broke through to Horsey Mere.

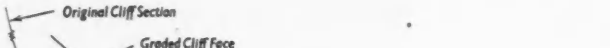


Fig. 15—Sea Wall at Kessingland

About 12,500ft of reinforced concrete stepped sea wall, as shown in the typical cross section, Fig. 11, is now being completed at Sea Palling, and to the south of that village. In the emergency stage of the work the sand dunes were reinstated and a depth of 5ft of sand was cleared from the village and its surrounding land. The dunes have now been planted with marram grass and fenced off. Some of the sand fill which is put behind the wall on completion, is excavated by scrapers, from the foreshore near the low-water mark, and then transported and placed in position. It will be noted that the top level of the wall is at +18·5 O.D., which is lower than the levels prevailing on the various other works which we have described, most of the top levels being above +20 O.D. The reason is that during the storm of January 31st it was found, in the experience of the consulting engineers, that walls of this particular design constructed to a level of 12ft to 13ft above the level of mean high water of spring tides were adequate to prevent damage to the land which they protected. On the night of January 31st the estimated still water level was +12·5 O.D. Newlyn, and the predicted level +5·0 O.D. ; the highest predicted spring tide level is +5·7 O.D.

The stepwork of the wall is built on top of a prepared sand formation, although in the southern part of the work clay is encountered at the lower levels. Holes are cored in the stepwork for subsequent grouting of the formation.

The wall was designed for construction in stages so that at each stage the work possesses an inherent stability. The stages are as follows : first, driving the steel sheet piles and the bearing piles ; second, the construction of the toe wall, the back wall (up to +12·5) and the transverse bulkheads, thus forming a rigid " box " system ; third, filling with sand between the bulkheads and sealing with concrete " ground centering " ; fourth, construction of the stepped wall ; fifth, construction of the parapet wave wall up to the finished level ; and, lastly, filling behind the wall with sand. The net cost of construction of this wall has been about £22 per foot run ; the gross cost, which includes the emplacement of the sand fill behind the walls and also the construction of steps, " pull-overs " and a return end wall, has been about £26 per foot run. Construction of the wall is shown in progress in Figs. 12 to 14.

This length of wall is noteworthy for the constructional plant layout with which rates of progress of 125ft to 150ft of wall per day have been attained. There is a central concrete plant at Sea Palling, which consists of an adaption of plant normally employed on airfield construction. Cement arrives in bulk, at a central weigh-batching plant. Coarse and fine aggregates are loaded into the hoppers of this plant by an excavator fitted with a grab. The batched quantities of coarse and fine aggregates and cement are discharged into a lorry which passes under the weighing hoppers. Each lorry has two compartments and can take two batches which are carried and discharged successively into the hopper of a double-drum mixing machine. This machine is well known on airfield work, and is mounted on crawler tracks and discharges the mixed concrete into a skip, which travels along the boom of the machine to the spot where it is required. In this application, however, the machine is employed as a stationary mixer and the boom is fixed above a hopper, into which the mixed concrete is discharged. Concrete lorries then back under this hopper to pick up a load of concrete, and carry it to where it is required along the length of the sea wall. The concrete lorry trips the hopper open and takes all the concrete—two full batches from the mixer. Two lorries have been sufficient to keep the mixer supplied from the batching plant. The plant is shown in Fig. 12.

Some of the concrete lorries travel by the existing coast road to one of various access roads to the sea wall ; others travel along the beach just in front of the wall. To keep a road open on the sand, which is above the normal high water mark, a water lorry is employed, continuously sprinkling the sand to keep it wet and firm, and trailing a small grader blade which continuously fills in the ruts caused by the traffic.

The steps of the sea wall are all concreted in one operation, for a length of 25ft, using a shutter forming the " risers " of the steps in a single rigid unit, in much the same manner as was done with the various other stepped walls we have described. The bull-nosed wave wall is built with a travelling shutter, in one lift. The concrete is emplaced by an excavator carrying a skip into which the concrete lorries discharge.

The scrapers used to carry the sand from the foreshore to the dunes have already been mentioned. Pile driving was done with a drop hammer on a small travelling piling frame or with an excavator with hanging leaders.

All 12,500ft of the new wall is being built from the one batching and mixing plant. A sea wall such as this is not a massive structure requiring the large quantities of concrete for which such elaborate plant is generally used, and in this case a good proportion of the work is taken up by steel fixing and shuttering. The layout, therefore, is probably something of an innovation for this class of work.

South of this wall we come to a length of 10,000ft where the dunes are more substantial and the protection does not yet include a sea wall. South again of this section the dunes were breached in 1938 and a concrete bagwork wall with a steel sheet piled toe was then built for a length of 9000ft. This wall was demolished last January for a length of 2000ft at the southern end. A new sea wall is being constructed to replace this damaged length and to extend the defences for a further 2000ft southward towards Winterton, to a point where the dunes again become both wide and high. The 4000ft of new sea wall very similar in its design to the stepped wall we have just described. On this length of wall, however, the plant employed is not quite so elaborate but the work is being carried out along similar lines, so no further details will be given here. These two sea walls are being built to the designs of Messrs. Lewis and Duvivier as consulting engineers, and the contractors are, respectively, John Laing and Co., Ltd., and Harbour and General Works, Ltd., for the 12,500ft and 4000ft lengths of the wall.

North of the first wall, between the two walls and south of the second wall, various lighter forms of protection are being provided. They all rely on the sand dunes to form the principal protection and much of the work consists of filling in the low parts of the dunes, and generally reinstating them and planting with marram grass.

There is a concrete bagwork wall with toe piles extending for 8000ft to the north of the first wall, part of which was damaged last January. It has been repaired and a sloping mass concrete slab apron added above the bagwork. To the north of this length, there

Fig. 16—Cliffs at Kessingland, February, 1953

are cliffs. A method used in the reinstatement of the dunes has been to build light groynes extending down the dune to the high water mark, to collect wind-blown sand. They consist of tubular steel rods driven into the dune and carrying four layers of chain link fencing with brushwood fixed between the layers. Such groynes have been very successful in collecting drifts of wind-blown sand.

In other areas as well considerable work has been carried out by the River Board. On the north Norfolk coast, the board has acted as consultant to the Wells U.D.C. and work rather similar to that from Wolverton to Hunstanton, described earlier, has been carried out. At Breydon Water, to give another example, embankments are being heightened and a railway embankment is being used as a second line of defence by fitting stoplogs to the under passes, so that they may be closed to prevent flooding. Major works have also been necessary near Aldeburgh and there has been extensive clay bank reconstruction in several areas. All these works mentioned above, with the exception of the ones where the consulting engineers are mentioned, have been carried out by the East Suffolk and Norfolk River Board, whose chief engineer is Mr. K. E. Cotton. The various contractors employed on these works apart from the ones already mentioned have been John Laing and Sons, Ltd., W. and C. French, Ltd., Aldertons, Ltd., Edmund Nuttall Sons and Co. (London), Ltd., R. Robinson (Contractors), Ltd., J. B. Edwards (Whyteleafe), Ltd., Dowsett Engineering Construction, Ltd., Marples Ridgeway and Partners, Ltd., May, Gurney and Co., Ltd., and the Dredging and Construction Company, Ltd. The Board's expenditure on all its sea defence works has been about £2,000,000, of which about £500,000 was spent on emergency works immediately after the disaster.

Protection Against Erosion

Under the Coast Protection Act, the division of responsibilities for sea defence is such that the river boards are principally concerned with low-lying coastal land, which is susceptible to flooding if the sea defences are breached. In areas where the coastal land is higher, the responsibility for sea defence often rests with the local authority. We have noted two cases above where river boards acted as consultants to a local authority; a number of other coastal local authorities in Norfolk and Suffolk have also carried out works as a result of the storm and tidal surge of January 31st, principally to combat coastal erosion, as opposed to protection from flooding. The damage caused by the flooding itself has received such prominence that this other aspect of the storm might perhaps, to some extent, have been overlooked. In fact there are examples, on the Norfolk coast particularly, where the very severe wave action at an exceptionally high tidal level, caused extensive destruction to sea walls and cliffs, and no little erosion resulted.

Fig. 18—Permeable Revetment at Caister

Fig. 15 shows a sea wall which may be regarded as typical of a number of structures recently erected by local authorities in Norfolk and Suffolk. The cliffs here are typically of poor materials, liable to slump when wet. The wall consists of a steel sheet piled cut-off with a reinforced concrete slab above it, forming a promenade, and giving a low bearing pressure upon the material beneath. On the landward side of this slab there is a wave wall against the cliff face. A generously dimensioned porous drain and weep-holes are built in here as the drawing shows. A sloping reinforced concrete slab is built against the cliff above the wave-wall, up to a coping level of about 21 O.D. or 22 O.D., where there may be a small bull-nosed coping, and the cliff is graded back above this point. In other cases, old walls which were damaged last January have been reinstated; at Overstrand sheet piles were driven in front of the damaged wall, which was then faced with new reinforced concrete work, with a promenade slab and shingle drain above, to give a rather similar cross section.

The wall at Kessingland has been built in conjunction with six "permeable" steel groynes, of a design developed by the consulting engineer. Each groyne consists of concrete-filled vertical tubular steel poles held at two levels, in horizontal steel channels; the groyne is built in zig-zag form to give it lateral stability. The space between each pair of tubes is approximately equal to the tube diameter; it is thought that this permeable construction offers resistance to eddies and waves, thus calming down the water sufficiently to allow material to settle. The "saw-tooth" beach profile produced by conventional groynes is thus avoided, and no erosive action to the lee of the permeable groynes has been observed. The success of the Kessingland groynes may be observed from Figs. 16 and 17, the photographic originals of which were both taken from about the same place. The pillbox shown on the foreshore extends 6ft to 8ft above the beach in the earlier illustration, and is nearly buried in the second, thus giving a measure of the accretion. The groynes themselves, also largely buried, may be observed in Fig. 17. Considerable success has been achieved with the permeable groynes built during this year's programme of works. At Walcott-Bacton, a system of twelve such groynes was installed; a newly-eroded channel has since filled and the high and low water marks have receded by 200ft to 300ft. The groynes in this case are about 350ft long; a rate of construction of one groyne in twelve working days was achieved. It is thought that the permeable groynes might actually promote erosion if the current flowing through them were fast enough, and much thought is given to each actual situation where they may be installed. As a rough rule a tidal current of 6 knots is considered the maximum where they would be effective. Fig. 18 shows a permeable revetment built on rather the same principle, to protect the foot of a cliff at Caister. It consists of a framework of timber piles, walings and braces, with random lumps of concrete placed inside. Three permeable groynes have been built in conjunction with this revetment, and the beach level is now about 1ft below the top waling. Such construction is cheaper to build than a sea wall, for the more isolated stretches of cliff, and several examples of steel and timber revetments have been constructed.

Fig. 17—Completed Sea Wall and Groynes—Kessingland, October, 1953

The reconstruction of the Overstrand sea wall mentioned above was carried out for the Erpingham R.D.C.; this council has a programme of works totalling about £100,000, as a result of last January's incident. Mundesley R.D.C. is building extensions to its sea walls and some revetments at a cost of some £30,000. Smallborough R.D.C. envisages an expenditure of about £500,000 on the protection of 2 miles of coast, including the groyning at Walcott-Bacton already referred to; about half of this work is in hand. A joint scheme at Caister, which it is envisaged will eventually cost £200,000, has been started by the Blofield and Flegg R.D.C. to the extent of about a fifth of the total amount. The works at Kessingland which we have taken as typical examples of all these works, are being undertaken by Lothingland R.D.C., all the works in this area totalling about £134,000.

The consulting engineer responsible to the various local authorities for the sea defences described in this section of our article is Mr. S. W. Mobbs. The works so far undertaken have been let principally to two contractors, May, Gurney and Co., Ltd., and M. Maclean, Ltd.

(*To be continued*)

Locomotive Valve Gears

By E. C. POULTNEY, O.B.E.

A comparative study is made of the relative performance of the Walschaerts and Stephenson's valve gears operating piston valves of equal diameters. The relative mean effective pressures developed in the cylinders are established on the basis of a defined speed in revolutions per minute and varying cut-offs and at a constant cut-off and varying speeds, the boiler working steam pressure being the same in each case.

IT is an accepted fact that the ability of any locomotive to haul trains is entirely dependent on the mean effective pressures developed in the cylinders at any rate of steam flow and assumed steam pressures. Further, for a given cylinder design, including port areas and the dimensions of the valves, the mean pressures attainable under equal operating conditions, as dictated by speeds in revolutions per minute and rates of admission, must be a function of the steam distribution obtained by the valve actuating gear employed. The object of the present discussion is to develop a comparison of the

TABLE I—*Mean Effective Pressures : Constant Speed —Varying Cut-Offs*

	W.R. " Hall " class engine		B.R. class " 4 " 4–6–0 engine	
Cut-off, per cent	Indicated tractive force, lb	Mean effective pressure, lb per sq in	Indicated tractive force, lb	Mean effective pressure, lb per sq in
10	5,400	38·0	3,950	29·1
15	7,500	53·0	5,400	40·5
20	9,250	65·0	6,650	50·0
25*	10,750	75·5	8,000	60·0
30	—	—	9,500	71·5
35	—	—	10,850	81·5

Constant speed—233 r.p.m.
* At a speed of 50 m.p.h., 233 r.p.m., the steaming capacity of the boiler and exhaust steam injector limited the maximum cut-off to 25 per cent when the cylinder feed was 21,690 lb per hour. Blidworth coal.

relative cylinder performance with a radial valve gear of the Walschaerts form, characterised by giving a constant opening to " lead " at all " cut-offs " per cent, and Stephenson's gear providing a variable " lead " opening increasing with a shortening of the " cut-off." The basic data upon which this investigation is founded is taken from *Test Report Bulletins*, Nos. 1 and 4, referring to tests carried

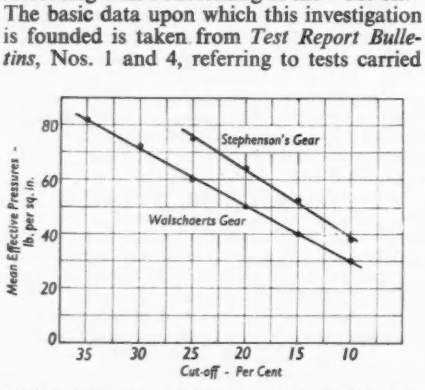


Fig. 1—Valve Gear Performance at Constant Speed

out on the Swindon testing plant with a " Hall " class W.R. 4–6–0 locomotive and a class " 4 " B.R. Standard 4–6–0 type locomotive. Writing in THE ENGINEER of April 3rd last, Dr. Tuplin, when discussing the speed range of various locomotives as influenced by grate areas in relation to tractive effort and as determined by valve proportions and the dimensions of cylinders and driving wheels, drew attention to the former Swindon practice of fitting Walschaerts valve gear to the G.W.R. four-cylinder engines and the use of Stephenson's gear for engines having two cylinders.

Dr. Tuplin, after commenting on the performance of these two locomotives, went on to remark as follows :—

" The fact that the former (four-cylinder engines) have Walschaerts gear and the latter (two-cylinder engines) Stephenson gear is an obvious difference between the two groups and has sometimes been mentioned as a possible reason for the (not certainly established) difference in operating characteristics, but the differences in valve events when pulling hard are extremely small and seem unlikely to have any perceptible effect on performance." Fortunately, through the enterprise of the Railway Executive, British Railways, the exhaustive tests already carried out with different locomotives, the results of which are made available, enable considerable reliable information to be had on various aspects of locomotive working, including performance data with Walschaerts and the Stephenson valve gears. This article may possibly be of interest in bringing out difference in performance as between engines with the gears mentioned, but does not claim to establish with " certainty " differences in performance except as between the specific engines compared.

Constant-Speed Variable Cut-Off and Mean Effective Pressures

The tabular statement, Table I, gives particulars of the indicated tractive efforts, as determined by an inspection of the diagrams given in the test report bulletins for a constant speed of 233 r.p.m. and, in the case of the " Hall " class engine, for cut-offs ranging from 10 per cent to 25 per cent, the speed being 50 m.p.h., at which the engine could not be operated at a longer cut-off per cent. The same information is also given for the class " 4 " B.R. Standard 4–6–0, but in this case the cut-offs range from 10 per cent to 35 per cent. The engine speed is 47·5 m.p.h.

Constant Cut-Off Variable Speed and Mean Effective Pressures

Table II gives the mean effective pressures developed in the cylinders when the cut-off is contant at 20 per cent, while the speeds vary from about 90 r.p.m. to 300 r.p.m. The numerical results taken from the tables are plotted in the accompanying graphs, those in Fig. 1 relating to Table I and those in Fig. 2 to Table II. It must be understood that the numerical values established have been computed from curves plotted in the test reports and not from numerical values. This has, however, been carefully carried out and the indicated tractive efforts so obtained have been checked with plotted indicated horse-power curves shown in the test reports and found in good agreement. The mean effective pressure values are, of course, estimated by dividing the indicated tractive efforts by the engine constants for tractive force per pound of mean effective steam pressure.

Engine Dimensions

The considerable differences seen to exist between the cylinder performance of these two engines are striking. Attention must therefore be given to the engine dimensions which affect cylinder power output. The following table, III, gives all the relative information, which includes information concerning the valve gears and port openings for admission, which are of prime importance.

Cylinder Feed

The steam taken into the cylinders per hour when the cut-off is 20 per cent and the

TABLE II—*Mean Effective Pressures : Constant Cut-Off—Varying Speeds*

	W.R. " Hall " class engine			B.R. Class " 4," 4–6–0 Standard engine		
Speed, miles per hour	Speed, revolutions per minute	Indicated tractive force, pounds	Mean effective pressure, lb/sq in	Speed, revolutions per minute	Indicated tractive force, pounds	Mean effective pressure, lb/sq in
20	94	10,150	71·7	99	8,800	66·0
30	140	9,900	69·9	148	7,800	58·8
40	186	9,600	67·7	198	7,150	53·8
50	233	9,250	65·0	247	6,500	49·0
60	280*	9,000	63·5	296	6,000	45·0
70	—	—	—	346	5,600	42·0

Constant cut-off 20 per cent. Blidworth coal.
* Maximum rate of cylinder feed 21,690 lb steam per hour reached at 280 r.p.m., 60 m.p.h., at the constant cut-off of 20 per cent.

speed 233 r.p.m. is, for the " Hall " (Stephenson gear) 18,100 lb per hour, and for the class " 4 " (Walschaerts gear) 12,100 lb. The " Hall " class engine cylinders take 49 per cent more steam, while the cylinder horse power developed is 1230 as against only 840 for the class " 4." The relative

TABLE III—*Dimensions of Engines*

Engine	W.R. " Hall " class	B.R. class " 4," 4–6–0
Cylinders :		
Diameter and stroke, inches	18·5 × 30	18 × 28
Working volume, cubic feet	4·66	4·12
Clearance volume, per cent	—	10·8
Boiler working steam pressure, pounds per square inch	225	225
Rated tractive force, pounds	27,275	25,515
Valve gear, type	Stephenson	Walschaerts
Valves :		
Type	Piston	Piston
Diameter, inches	10	10
Maximum travel, inches	6·91	7·34
Steam lap, inches	1·75	1·687
Lead opening, full gear, inches	0·18	0·25
Port opening, admission :		
Full gear, inches	1·7	2·0
At 20 per cent cut-off, inches	0·275	0·335
Lead opening, admission :		
At 20 per cent cut-off, inches	0·15	0·25
At 20 per cent cut-off, per cent of port opening	54·5	74·5

Cylinder Performance at 20 per cent Cut-Off and 233 r.p.m.

Speed :		
Revolutions per minute	233	233
Miles per hour	50	47·5
Steam to engines :		
Pounds per hour	18,100	12,100
Per revolution	1·29	0·87
Indicated tractive force, pounds	9,250	6,650
Mean effective pressure, pounds per square inch	65·0	50·0
Indicated horsepower	1,230	840
Steam per indicated horsepower-hour, pounds	14·7	14·4
Cylinder thermal efficiency, per cent	13·4	13·7

cylinder working volumes of the " Hall " and the class " 4 " engines are, respectively, 4·66 and 4·12 cubic feet ; thus, the capacity of the " Hall " cylinders is 13 per cent greater, but the power developed is greater by 46 per cent as compared with the class " 4 " engine. Other things being equal, the powers developed should be proportional to the cylinder steam supply. However, in this case, the steam conditions differ in the temperatures and the amount of superheat

carried by each pound of cylinder feed. The steam used by the class "4" cylinders is hotter and carries more superheat: thus, for a given volume of steam supplied, the weight of steam is less. What the actual relative volumes were during these tests cannot be computed because the reports do not give steam chest pressures.

In the case of each of the locomotives, the boiler working steam pressure is the same, namely, 225 lb per square inch: further the steam temperatures and the amount of superheat are given as being 570 deg. and 170 deg. Fah. and 610 deg. and 210 deg. Fah. for the "Hall" and class "4" locomotives; the specific volumes cubic feet per pound of steam are, therefore, on this basis 2·44 and 2·58, respectively. The specific volumes of the steam actually taken into the steam chests

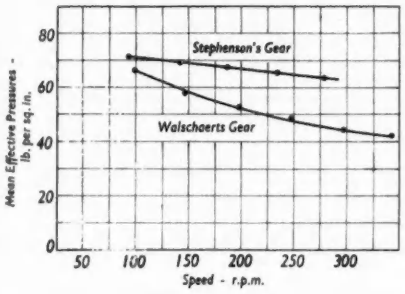


Fig. 2—Valve Gear Performance at Constant Cut-off

are possibly in closely the same ratio. The "Hall" cylinders are 13·0 per cent larger, but the specific volume of the cylinder feed steam is some 5 per cent less, while the actual weight of steam supplied is greater by as much as 49 per cent. Comparing the working volumes of the cylinders and the assumed specific volumes of the admission steam, it will be seen that the steam intake for the "Hall" cylinders would be 20 per cent greater, whereas it is shown by the test data to be 49 per cent; further, the "Hall" cylinders utilise this greater weight of steam with practically the same efficiency as the class "4," the respective steam rates being 14·7 lb and 14·4 lb per i.h.p. hour.

Mean Effective Pressures

The tabulated data and the graphs (Figs. 1 and 2) will, it is thought, bring out the differences between the cylinder performance of these two locomotives which, in view of the very small potential variation in the power capacity of the cylinders at equal rates of admission and speeds revolutions per minute are, to say the least of it, very interesting. Other governing factors being equal, the "Hall" with 13 per cent more cylinder working volume, should at equal crank speeds develop 13 per cent more power, whereas the recorded power output was greater by 46 per cent.

The larger part of this increase in power output is, therefore, due to a higher mean pressure developed in the cylinders at a "cut-off" of 20 per cent common to both engines. Dr. Tuplin appears to think that "differences in valve events when pulling hard are extremely small and unlikely to have any perceptible effect on performance."

Perhaps the graphs reproduced in Fig. 1 may throw some light on this aspect of the case, for the reason that if by the term "working hard" an increase in admission rates is envisaged the plot indicates that Stephenson's valve gear shows to even greater advantage at 25 per cent cut-off than it does at 10 or 15 per cent.

Admission and Exhaust Port Openings

Admission takes place between "pre-admission" and "cut-off," while "exhaust" begins at the point of "release" and extends until the valve closes and the period of "compression" reached. Both "admission" and "exhaust" are, therefore, seen to be the controlling events in the steam distribution in the cylinders. In the case of valve gears of the kind under review, shortening of the rate of "cut-off" is accompanied by considerably reduced port openings for "admission," while at the same time with long travel gears a full port is at all times available for "exhaust."

Modern practice tends to the use of much larger piston valves in relation to cylinder sizes than formerly, presumably in order to enlarge port areas for "admission" steam at early rates of "cut-off" required to efficiently utilise high pressure steam. The use of large diameter piston valves for the purpose stated, coupled with full port openings to "exhaust" at all "cut-offs" tends to a free exhaust which, however desirable, also tends to cause "cylinder pressure to vanish" following "release." It is perhaps more noticeable at high speeds and at the earlier rates of "cut-off," though an inspection of indicator diagrams usually shows clearly defined "release" points, distinguished by a more or less pronounced fall in pressure, meaning some loss in the area of the diagram. Obviously, by the use of a one-piece valve controlling both "admission" and "release" any difficulties of this kind are unavoidable. Piston valves have never been too large so far as "admission" is concerned, though it is possible that the same cannot be said concerning "exhaust." The facts are that piston valves and valve gears at the best only offer a compromise between conflicting conditions and that such valve gears appear to have reached the limits of their capacity.

National Physical Laboratory Interferometer*

By D. C. BARNES A.M.I.Mech.E., and M. J. PUTTOCK, B.Sc.†

An interferometer made at the National Physical Laboratory, Teddington, in 1937, for routine measurements of the length dimension of slip and block gauges had a measuring capacity limited to slip gauges of 2in length. In the new model described here a mercury-198 lamp is used as well as a cadmium lamp and the measuring capacity is increased to 4in. The new instrument is more compact and convenient in use.

Introduction

During 1937 an interferometer was designed and made in the Metrology Division of the National Physical Laboratory for routine measurements of the length dimension of high quality slip or block gauges to an accuracy of $\pm 1 \times 10^{-6}$in (0·025μ). Measurements are based on the lengths of waves of light which are accurately known in terms of the inch and the millimetre. An important feature of the design of the N.P.L. interferometer is that batches of up to eighteen gauges or so of differing sizes can be set up for measurement in one operation. The essential observations of the interference fringe patterns are made in red, green, blue and violet light from a cadmium hot-cathode discharge lamp of the "Osram" laboratory type. Apart from the red radiation, the monochromatic quality or purity of cadmium light limits the measuring capacity to slip gauges of 2in (50mm) length.

The introduction of improved sources of monochromatic light, in which a pure isotope of mercury or krypton is used instead of the natural substance as the radiating element, has considerably extended the range of length which is directly measurable by the interference method[1]. In the new model of the N.P.L. interferometer to be described a mercury-198 lamp is employed, as well as the cadmium lamp, to increase the measuring capacity to 4in (10cm), thus including the complete range of sizes supplied in the usual sets of slip gauges. At the same time the new instrument is much more compact than the earlier model, and the improved controls provided for the optical and mechanical adjustments are arranged for the greater convenience of the observer.

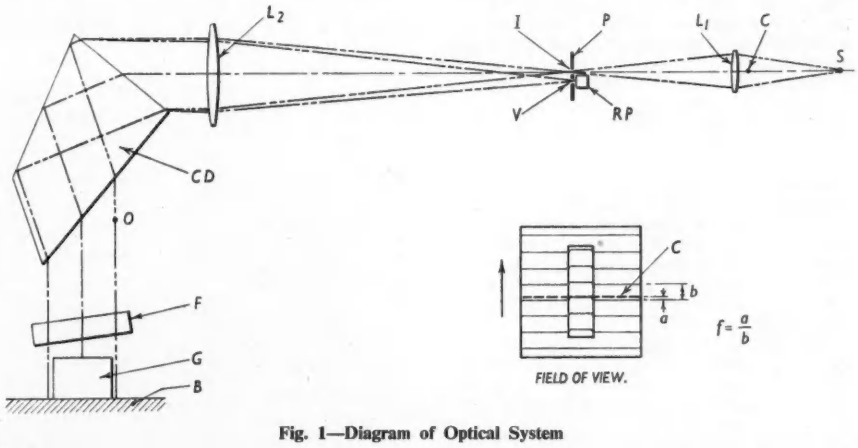


Fig. 1—Diagram of Optical System

Optical Principle and General Arrangement

The optical principle and general arrangement of the N.P.L. interferometer are well-known,[2] but it will be useful to outline their main features before describing the new model. Referring to the diagram in Fig. 1, light from a source of monochromatic light S is condensed by lens L_1 on the illuminating aperture I in plate P situated in the principal focal plane of the

*Communication from the National Physical Laboratory.
†Now at the National Standards Laboratory, Sydney, N.S.W.

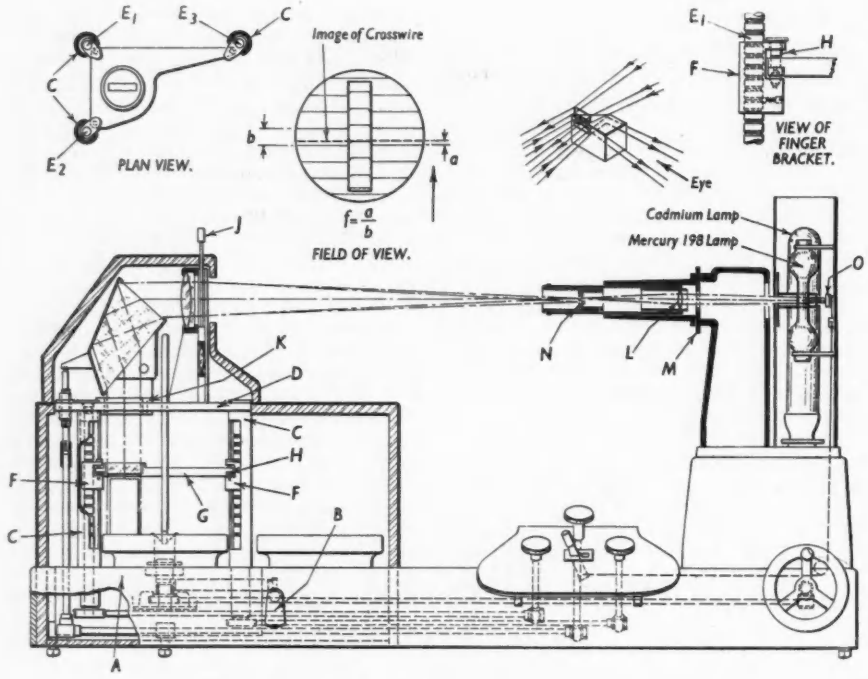


Fig. 2—0in-4in (100mm) Type "B" Gauge Measuring Interferometer

collimating lens L_2. The parallel beam from L_2 is directed into the constant deviation prism CD which disperses the light into its several constituent beams of differing colours. These constituent beams are transmitted and reflected downwards by the prism in slightly different directions. A micrometer screw control, provided for rotating the prism about an axis O perpendicular to the plane of the diagram, enables the observer to select one beam of a particular colour and direct it vertically downwards.

The slip gauge G to be measured is wrung to the flat, lapped surface of a hardened steel base-plate B. Above this combination is placed, on finely adjustable supports, a glass optical flat F which is suitably inclined at a small angle (usually about 10 seconds) to the base-plate. The wedge (or Fizeau) interferometer thus formed is illuminated with the parallel beam of monochromatic light from the constant deviation prism.

The incident beam is divided by reflection and transmission at the lower surface of the optical flat F, the transmitted light being subsequently reflected partially at the upper surface of G and partially at the surface of B. After a second transmission at the lower surface of F this reflected light, together with the light directly reflected from the lower surface of F, retraces (approximately) the path of the incident light back to plate P where it is received in the viewing aperture V. Behind V is a small reflecting prism RP which deflects the light into the observer's eye placed close to RP.

The field of view displays two series of interference fringes consisting of parallel dark bands or lines on a bright background. One series of fringes, produced by interference between the light reflected from F and that reflected from G, is superposed over the surface of the slip gauge; the other series, produced by interference between the light reflected from F and that reflected from B, is superposed over the surface of the base-plate. An estimation is made of the relative displacement a between the two series of fringes expressed as a fraction f of the fringe spacing b, where $f=a/b$. This value of f, representing the excess fraction of a wavelength of light contained in twice the length of the slip gauge, can usually be estimated by eye to 0·05, equivalent to about $0{\cdot}5 \times 10^{-6}$in ($0{\cdot}01\mu$) in the length of the gauge. To aid estimation by eye a cross wire C, mounted in an adjustable frame attached to the support for the lens L_1, may be used by setting it so that its image in the field of view coincides with a fringe on the gauge.

The estimations of excess fractions are made at the centre of the surface of the gauge in three or four monochromatic radiations of differing colours (or wave-lengths). The length of the gauge is then quite simply derived by comparing the observed excess fractions with tabulated standard values; any difference is evaluated by using a special slide rule which gives the result expressed as a difference from the nominal length of the gauge.

The temperature at which the measurement of length is made is observed by means of a standard mercury thermometer, and the result given by the slide rule is corrected to the corresponding value of the length at 20 deg. Cent. At the same time small corrections are also applied for the effect on the wave-length of light of any departures of atmospheric temperature, pressure and humidity from certain standard conditions.

Reference has already been made to the facility for measuring gauges in batches. This is achieved by using a rotatable base-plate of which the upper and lower surfaces have a lapped finish and are flat and parallel to a high degree of precision. The lower surface rests on another flat, lapped surface. This combination is similar to that employed in the well-known Level Comparator of N.P.L. design and has the important property that the upper surface is maintained accurately within its own plane when the base-plate is rotated. A batch of slip gauges may be wrung in a suitably spaced radial arrangement on the surface, and each gauge is brought in turn to the centre of the field of view by rotating the base-plate.

Description of the New Model

All the features of the optical system and general arrangement already described can be recognised in the schematic drawing, Fig. 2, of the new model of the N.P.L. interferometer. Fig. 3 is a general view of the front of the instrument with a hinged portion of the gauge enclosure open and Fig. 4 is a close-up view of the lamp-house and associated parts, as seen from the rear of the instrument, with the front of the lamp-house cover removed. For the purposes of further description the following principal units are considered in turn: (*i*) the base-plate assembly; (*ii*) the illuminating and viewing assembly and (*iii*) the main bed and control panel.

(*i*) *Base-plate Assembly* (*Fig.* 2).—The base-plate for the gauges is rotatable upon a base casting A about an axis defined by a central locating peg. Rotation of a worm-wheel fixed to the lower end of this peg is transmitted to the base-plate by a cross-pin fitting into a groove. The worm-wheel is driven by a worm-shaft situated beneath the base casting. By pulling the knob B, which actuates a rack and pinion and thereby an eccentric pin, the locating peg may be retracted. The base-plate can then be simply removed from the base casting by sliding it out of position. A shallow eccentric groove, machined in the under face of the base-plate and connecting with a hole in the side of the base-plate, may be flooded with paraffin to prevent wringing of the surfaces.

The arrangements for varying the height of the optical flat and for fine adjustment of its inclination are constituted as follows.

Three slotted tubular pillars C, located as shown in the inset plan view, are linked together at their tops by a plate D to maintain parallelism and rigidity. Each pillar is bushed at both ends

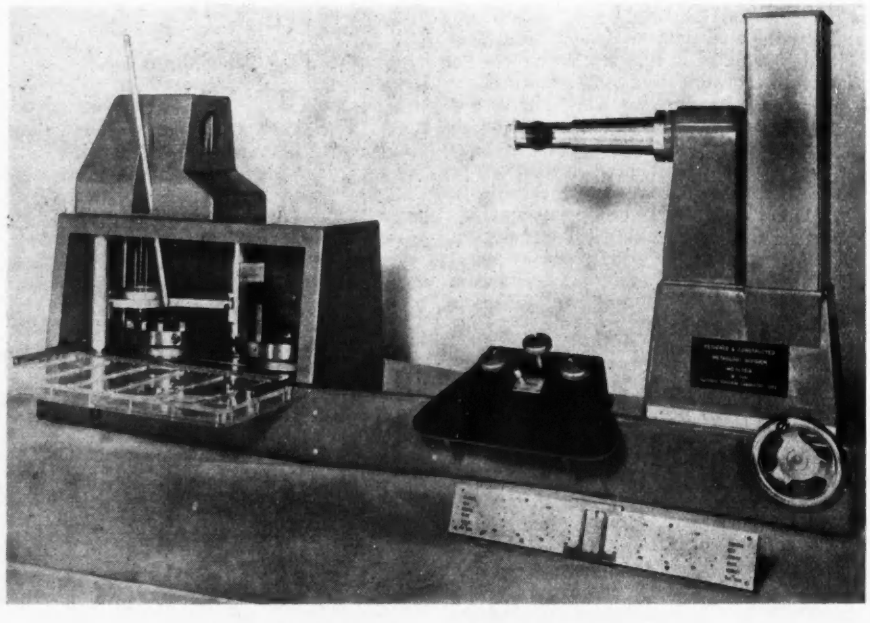


Fig. 3—Front View of Gauge Measuring Interferometer

to guide a hardened steel rod provided with circumferential grooves ground at 0·2500in (6·35mm) intervals along its length. The grooved rod E_1 is pinned to its lower bush and pillar and is thereby fixed. The other two rods, E_2, E_3, have threads at their lower ends engaging with a nut in the form of a worm-wheel; as each of these rods is constrained by a pin protruding into an axial slot, rotation of the worm-wheels provides a very fine control of the vertical movements of the rods. The worm-wheels are driven by worms mounted upon horizontal shafts situated beneath the base casting.

Three finger brackets *F*, each machined to be a sliding fit upon its grooved rod and in the vertical slot in the associated pillar, may each be indexed in 0·2500in (6·35mm) steps by a spring-actuated ball entering successive grooves, (see enlarged view inset). Each finger-bracket has a cone-shaped recess in the upper surface of its lower limb to retain a hardened steel ball upon which the holder *G* for the optical flat is kinematically supported by cone, vee and plane fittings. The upper surface of each of these fittings is spherically formed about a point coincident with the centre of the corresponding ball. A flat anvil *H*, mounted in the upper limb of each finger-bracket, contacts the spherical surfaces of the fitting and retains the holder *G* in a suitable manner whatever the relative positions of the finger-brackets on the grooved rods. Coarse adjustment of the height of the optical flat is made by moving the holder and its associated fittings upwards or downwards by hand to the desired position on the grooved rods and leaving it in a condition which is nominally parallel to the base-plate. A divided scale fixed to one of the pillars is used as a guide to the height. Fine control of the inclination of the holder about two horizontal axes at right angles is obtained by means of the two grooved rods E_2, E_3, which are adjustable in a vertical direction.

The collimating lens, of focal length 21½in (54·6cm) and aperture 2⅜in (6cm), is mounted in a bracket fitted to the plate *D*. An auxiliary lens of focal length about 26in (67cm) only, used when setting up the apparatus, can be brought into position in front of the collimating lens by means of the control rod *J*.

The constant-deviation prism is constructed in borosilicate crown glass of refractive index 1·516 (reciprocal dispersive power 63·1) and has an aperture in the form of a square with 1·75in (44·5mm) side. It is supported in a bracket mounted on a base *K* which can rotate by a limited amount on the plate *D* about a vertical axis situated in the centre of the field of view. Finely threaded opposing tangent screws provide a means of adjustment for this rotation whereby the prism may be correctly orientated with respect to the optical axis of the interferometer. The prism is mounted within a suitable protective holder which may be rotated about a horizontal axis upon centres fixed to the bracket. A hardened steel ball at the end of an arm extending from the prism holder contacts the anvil of a micrometer screw set vertically in the plate *D*. The micrometer screw is driven by a vertical shaft extending upwards from the base casting. A spiral gear fitted to the bottom end of this shaft engages with a similar gear on a horizontal shaft situated beneath the base casting.

The complete base-plate assembly is supported by three adjustable feet fitted to the base casting.

(*ii*) *Illuminating and Viewing Assembly* (*Figs.* 2, 3 *and* 4).—The illuminating and viewing assembly incorporates the lamp-house and the adjustable tubular unit projecting from a bracket towards the collimating lens. The tubular unit carries the condensing lens *L* of focal length 2·4in (6cm), the adjustable cross-wire fitting *M* and the system *N* comprising two slit apertures and a small reflecting prism situated behind the lower aperture. Light from either the cadmium lamp or the mercury-198 lamp is directed by the deflecting mirror *O* towards the condensing lens which focuses an image of the source on the upper slit aperture. The reflected light returning from the interferometer is received in the lower slit aperture and is reflected outwards by the small right-angle prism so that the observer may view the interference patterns.

More details of the elements of the slit system and reflecting prism are shown in Fig. 5. A rectangular window of adjustable dimensions is formed by the bevelled edges of two pairs of plates which can slide between fixed guides. One of the plates carries a bevelled reed of about 0·02in (0·5mm) width dividing the window into two rectangular apertures or slits. The movable plates can be clamped in position after adjusting the widths and length of the slits with the aid of wire setting pieces of suitable diameter. The actual dimensions used in the new model are: length 0·0298in (0·757mm), width of illuminating aperture 0·0130in (0·329mm), width of viewing aperture 0·0141in (0·358mm); the separation of the centres of the two slits is 0·0321in (0·815mm). Adjustable

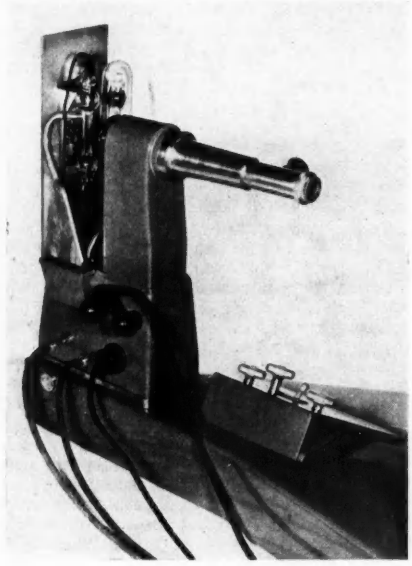


Fig. 4—Illuminating and Viewing Assembly

slit apertures are used instead of the fixed circular apertures of the original model of the interferometer because the former are more suitable for resolving the two yellow rays of the spectrum of mercury-198 into separated images at the viewing aperture.

The rear view of the lamp-house and associated parts (Fig. 4) shows the electrical and water supply connections to the two lamps; the water is provided for cooling the mercury-198 lamp and is supplied from the mains, preferably at a temperature within the range 18–22 deg. Cent. The cadmium lamp is operated from the 230V a.c. mains in series with an external ballast resistance for limiting the current to the range 1–2A. The G.E.C. mercury-198 lamp, of the cold-cathode type,[3] is excited at 750V by means of a transformer from the 230V mains, the current through the lamp being limited to 25mA with the aid of a series-connected choke (50H).

(*iii*) *Main Bed and Control Panel* (*Figs.* 3 *and* 4).—The parts already described are assembled on the main bed which is fabricated from plates of aluminium alloy. The main bed also carries the control panel set at 30 deg. to the horizontal in a convenient position underneath the viewing station for ease of manipulation. Rotation of the three control knobs on the panel is transmitted, by means of spiral gears and horizontal shafts situated in the bed, to the adjusting devices associated with the optical flat and the constant-deviation prism. The rearmost knob (Fig. 2) controls rotation of the prism and thus the selection of the monochromatic light in which the observations are made. Orientation of the fringes is controlled by the knob on the left of the panel which is connected to the grooved rod E_2; suitable adjustment brings the fringes into parallelism with the shorter edges of the surface of the slip gauge, as shown in the inset diagram of the field of view. Fringe spacing is under control of the knob on the right of the panel connected to the grooved rod E_3. The lever control at the centre of the panel is connected by cord to a bell-crank lever operating, against the reaction of a spring, the deflecting mirror *O* in the lamp-house. This mirror has two positions determined by stops which are adjusted so that the light from one lamp or the other can be directed into the illuminating aperture of the interferometer. The hand-wheel at the extreme right of the main bed controls rotation of the base plate for the gauges. A fourth adjustable supporting foot, supplementing the three supporting feet under the base-plate assembly, is provided at the right end of the main bed.

The whole of the base-plate assembly at the left of the main bed is enclosed in a cover constructed mainly of sheet aluminium lined with "Onazote" to provide good thermal insulation. This cover is constructed in two separately removable parts, the lower having a hinged cavity wall at the front made of two "Perspex" panels separated by an air space. The upper cover, located on the lower, may be removed to obtain access to the constant-deviation prism and the collimating lens. The surface of the base casting underneath the covers is also lagged with "Onazote."

When the hinged portion of the lower cover is open, as in Fig. 3, access is provided to the main enclosure for assembly of the rotatable base-plate and gauges. The enclosure is large enough to store another batch of gauges on a second base-plate which can be transferred with its gauges to the measuring station when the observations on the first base-plate are concluded. This facility provides means for setting up some thirty-five gauges for measurement in two operations, between which a short interval of, say, thirty minutes is allowed for temperature stabilisation.

The temperature of the gauges is observed by means of a standard mercury thermometer, divided to 0·01 deg. Cent. and calibrated to ±0·002 deg. Cent., placed with its bulb resting in a metal cone inserted in a hole at the centre of the rotatable base-plate. The thermometer is read with the aid of a magnifying lens. This arrangement is suitable for determining the temperature of slip gauges up to 1in (25mm) length. For longer gauges the bulb of the thermometer rests in a conical recess at the top of a steel pillar, located in the hole at the centre of the base-plate, which is of suitable height to raise the centre of the bulb to a position about 1·75in (44·5mm) above the surface of the base-plate. Performance tests have established that the temperature of the longer gauges can be obtained by this means to about 0·01 deg. Cent., provided the interferometer is used in a room thermostatically controlled at 20 deg. Cent. within ±0·25 deg. Cent. and that a sufficient period, say three hours, is allowed for temperature stabilisation after wringing the gauges and placing the base-plate in the measuring station. In other circumstances, and also if greater precision in temperature measurement is required, it would be advisable to use thermocouples to relate the temperature of the gauges to the reading of the standard thermometer.

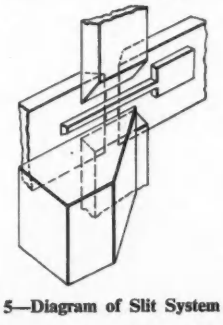


Fig. 5—Diagram of Slit System

Adjustment of the Optical System

Experience has shown that the optical system, once adjusted, remains in satisfactory alignment and does not require much subsequent attention. In routine work the height of the holder for the optical flat needs to be frequently changed, but the locating arrangements provided for the holder are so designed that the fringes rarely disappear after making a change. If they do the auxiliary lens is drawn up by means of the

control rod *J* (Fig. 2) in front of the collimating lens. With this combination of lenses two or more series of coloured images of the illuminating aperture appear in the field of view. The brightest of these series is formed in light reflected from the surfaces of the base-plate and gauges ; the others are due either to light reflected from the lower surface of the optical flat or to multiple reflections between this surface and the surfaces of the base-plate and gauges. The two knobs provided to actuate the grooved rods E_2 and E_3 for fringe control are then adjusted so that the various series of images are superposed over the series due to light reflected from the base-plate and gauges. In this condition and after moving the auxiliary lens out of the field of view, the beams reflected from the various surfaces of the interferometer are appropriately directed on to the viewing aperture for the observation of fringes. Fine adjustments of the orientation and spacing of the fringes can then be made.

The sense in which the relative displacement *a* (Figs. 1 and 2) is to be estimated depends on the disposition of the wedge-shaped gap between the optical flat and base-plate. For consistency the inclination of the optical flat is arranged so that the fringe order numbers increase upwards, i.e., the open end of the wedge is upwards in the field ; *a* is then estimated in the upwards direction from the adjacent base-plate fringe.

It is advisable to check periodically that the image of the illuminating aperture fills the viewing aperture by examining the latter through the reflecting prism with the aid of a magnifying lens when the constant-deviation prism is set in turn to select the red and the violet radiations of cadmium. If the image is displaced in the horizontal direction with respect to the viewing aperture, a correction is made by adjusting the supporting bracket for the constant-deviation prism about its vertical axis, using for this purpose the opposing tangent-screw adjustments previously mentioned.

The Optical Flat

The surfaces of the glass optical flat, which is 2·25in (57mm) in diameter and 0·75in (19mm) in thickness, are both plane to well within 0·1 of a fringe (mercury green light) and are inclined to one another at an angle of about 5 minutes. Thus when the lower surface is appropriately adjusted with respect to the base-plate and gauges for the viewing of fringes, the light reflected from the upper surface is deflected out of the field of view. A layer of bismuth oxide is deposited on the lower surface to increase its reflecting power. This layer is deposited by a sputtering process[4] from a pure bismuth cathode in an atmosphere at low pressure consisting mainly of argon mixed with a small amount of air, and the thickness is such that the first reflection-maximum (intensity about 38 per cent of the light incident normally on the surface) occurs in the blue-green region of the spectrum. Very fine dark fringes on a bright field are obtained, partly because the reflecting power of the treated surfaces approximately matches that of lapped hardened steel surfaces (35–40 per cent) and partly because of the effect of multiple reflections between the treated surface and the surfaces of the base-plate and gauges.

Results of Performance Tests

A performance test of the new model was made by measuring six gauges from a laboratory standard metric set. Table I compares the results of this test with those obtained on three previous occasions when the measurements were made in the original model of the interferometer. Values of the length L_{20} of each gauge at 20 deg. Cent. are expressed as the differences $(L_{20}-L_n)$ in fractions of 1μ (0·000039in), where L_n is the nominal length.

The results in Table I indicate not only that the reproducibility of the two instruments is within ±0·01μ (±0·4 × 10⁻⁶in), but that the gauges are remarkably stable in size. All the observations were made in terms of the wavelengths of red, green, blue and violet light from an " Osram " cadmium lamp.

Table II shows the results of another performance test made on a series of five gauges ranging in size from 1mm to 100mm. In this case the results of measurement in the new model denoted by NB in the table, are compared with those made in a Kösters-Zeiss interferometer, denoted by KZ, which utilises an optical principle similar to that of the well-known Michelson interferometer. The lengths refer to the standard temperature 20 deg. Cent.

Here again the reproducibility of the mean values of length determined in the two interferometers is of the order of ±0·01μ (±0·4 × 10⁻⁶in) or better throughout the range of measurement. In the N.P.L. interferometer wavelengths of the four radiations from an " Osram " cadmium lamp were used as the bases of measurement in the range from 1mm to 25mm ; the 100mm gauge was measured in terms of the wave-lengths of the cadmium red, the mercury-198 green and the mercury-198 violet radiations. All the results relating to the Kösters-Zeiss interferometer in Table II were obtained with the aid of a mercury-198 lamp alone.

Acknowledgments are made to Mr. F. H. Rolt, O.B.E., for his suggestions, to Dr. H. Barrell for advice on the design adjustment and testing of the new instrument, to Mr. J. W. Simmons and Mr. E. P. Goymour, who were responsible for its construction, and to Mrs. P. Anderton and Miss F. Geddes, who carried out the performance tests.

The work described above has been carried out as part of the research programme of the National Physical Laboratory, and this article is published by permission of the Director of the Laboratory.

Table I—*Results of a Performance Test in the Range 1mm to 25mm (unit = 1μ)*

Nominal length (mm)	N.P.L. Interferometer, Original Model (*A*)				New Model (*B*)	Difference (*B*—*A*)
	November, 1947	October, 1949	November, 1951	Mean	August, 1952	
1·12	+0·079	+0·071	+0·076	+0·075	+0·076	+0·001
1·49	−0·064	−0·061	−0·069	−0·065	−0·071	−0·006
3·00	+0·048	+0·030	+0·038	+0·039	+0·041	+0·002
6·00	+0·023	+0·005	+0·008	+0·012	+0·015	+0·003
12·5	+0·025	0·000	+0·003	+0·009	+0·018	+0·009
25·00	+0·020	+0·038	+0·036	+0·031	+0·036	+0·005

Table II—*Results of a Performance Test in the Range 1mm to 100mm (unit = 1mm)*

Nominal length (mm)	Interferometer	Left or marked face of gauge upwards	Right or unmarked face of gauge upwards	Mean length (20 deg. Cent.)	Differences (*NB*—*KZ*) (μ)
100	NB	100.000 126	100.000 104	100.000 115	+0·010
	KZ	100.000 109	100.000 102	100.000 105	
25	NB	25.000 025	25.000 018	25.000 021	−0·008
	KZ	25.000 032	25.000 026	25.000 029	
10	NB	9.999 990	10.000 003	9.999 996	−0·009
	KZ	10.000 003	10.000 008	10.000 005	
5	NB	5.000 007	5.000 007	5.000 007	+0·011
	KZ	4.999 997	4.999 996	4.999 996	
1	NB	1.000 008	1.000 012	1.000 010	+0·002
	KZ	1.000 010	1.000 006	1.000 008	

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[2] Barrell, H., *Research*, 1948, Vol. 1, page 533.
[3] Harris, N. L., The Engineer, 1950, Vol. 190, page 409.
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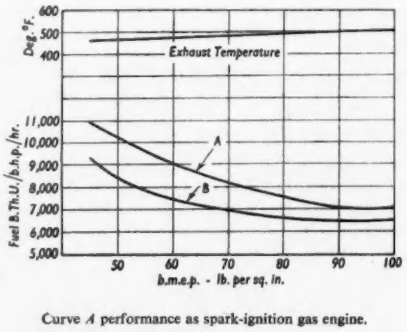
Supercharged Gas Engine

It was in 1889 that the National Gas and Oil Engine Company, Ltd., began manufacturing gas engines and during the intervening years development has been continuous, while, in addition, the company has also been engaged largely in the production of a wide range of diesel engines for both industrial and marine purposes. Engines were produced to run on sewage gas, and in 1938 the company introduced the dual-fuel engine, an engine which was capable of running on either gas or oil or a combination of both. The compression ratio equivalent to that in diesel engines was used for the normally aspirated gas engine, and ignition was by means of an injection of a small quantity of diesel fuel. The amount of gas and oil was regulated by a simple adjusting screw.

The possibilities of the dual-fuel engine have continued to occupy the attention of the company, but development was retarded during the war and during the immediate post-war years. However, since then progress has been made and a diesel engine was introduced which incorporated spark ignition and could be changed over to operate on gas without the use of diesel fuel ; it could also operate as a dual-fuel engine. We reproduce herewith in Fig. 1 the performance curves of a Mark M4AGP6 engine, which can operate as a diesel engine, spark ignition gas engine or dual-fuel engine at a brake mean effective pressure of 90 lb per square inch on town's gas. The engine has a bore and stroke of 6in and 8·5in respectively, and a compression ratio of 12 to 1, and develops 165 b.h.p. at 1000 r.p.m.

Due to pressure charging the diesel engine continued to be in advance of the gas engine and to increase the power of the latter engine to be comparable with that of the diesel engine has been the objective of the company's development department during recent years. The experimental work has been carried out on a single cylinder having a bore of 12in and a stroke of 15in, and a speed of 428 r.p.m., with gas and air being delivered by Roots blowers. In addition to the usual compressed air starting valve the cylinder head as developed contains an air inlet and an exhaust valve each in separate cages, that for the exhaust valve being water cooled. Gas and air are not mixed before entering the combustion chamber, but are delivered separately to be mixed subsequently, the gas being admitted to the cylinder through a conventional poppet valve push rod operated from a separate cam on the camshaft. Our diagram, Fig. 2, shows that the gas is injected into the cylinder of the four-stroke cycle engine over a predetermined part of the induction



Curve *A* performance as spark-ignition gas engine.
Curve *B* as dual fuel engine.

Fig. 1—M4APG6 Engine Consumption Curves

stroke, during which the exhaust valve is closed, and also that gas is not permitted to pass through the cylinder during the scavenging period. Scavenging of the cylinder is obtained as on the exhaust supercharged oil engine working on the Buchi principle.

Butterfly valves were eventually adopted as the means of flow control and they were fitted in the gas and air inlet pipes and operated by the mechanical governor. The linkage could be adjusted to suit running conditions and it was

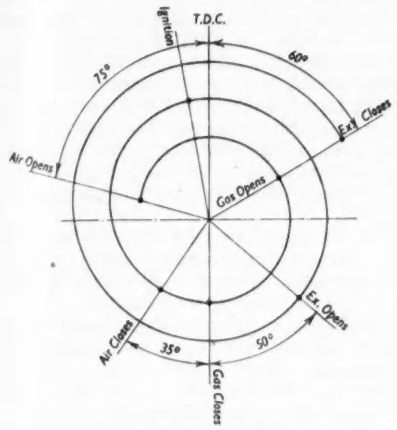


Fig. 2—Engine Cycle

found that this arrangement for controlling the mixture at varying loads gave the best performance over the load range. During the tests the gas flow was measured by a Kent curved tube manometer inserted in the gas pipeline before the gas booster, which was operated by the pressure difference across a calibrated orifice plate and the readings were corrected for variations of pressure and temperature in the gas line. Cylinder conditions were observed by means of a "Sunbury" cathode-ray oscillograph, which gave no indication of detonation occurring. At 120 b.m.e.p. the maximum pressure was 740 lb per square inch and the engine ran for 600 hours at this brake mean effective pressure. The performance obtained at a compression ratio of 10 to 1 using town's gas having a hydrogen content of about 50 per cent is shown in Fig. 4.

Following the success of the experimental work with a single cylinder, attention was turned to applying the tests to a multi-cylinder engine and the six-cylinder Mark F4AU engine in the works power-house, which has a bore of 11in by 15in stroke, was adapted for the tests by fitting new cylinder heads. Pressure charging is by a Brown Boveri exhaust gas-driven supercharger on the Buchi system with after cooling of the compressed air, while the town's gas, which is available at 5in water gauge, is boosted to 6 lb per square inch by a Roots blower. An intercooler is fitted at the blower outlet to assist in the study of the effect of gas temperature on engine performance.

Ignition is by high-tension magneto which is driven, together with the air distributor for compressed air starting, from the free end of the crankshaft. The air and gas throttles are operated by a common rocking shaft coupled to the governor, and the gas throttles, of which there is one to each cylinder, are connected to the rocking shaft by adjustable links which permit the load between the cylinders to be balanced. Our illustration, Fig. 3, gives a general view of the engine and shows the rocking shaft and linkages. Up to date the engine has run satisfactorily at loads up to 130 lb per square inch brake mean effective pressure with a corresponding gas consumption of 6800 B.Th.U. per brake horsepower per hour, which equals a brake thermal efficiency of 37·4 per cent and is equivalent to a consumption of 0·368 lb per brake horsepower per hour of fuel of calorific value of 18,500 B.Th.U. per pound. These results indicate that the pressure charged gas engine is capable of power and thermal efficiency which is on par with most commercial diesel engines.

The company is now producing a range of supercharged gas and dual-fuel engines, Mark F2AUG and Mark B2AUG, both marks being vertical four-stroke, pressure-charged engines, with electric ignition and compressed air starting. The F2AUG engines have a 12in bore by 15in stroke, a full-load brake mean effective pressure of 121 lb per square inch, a maximum governed speed of 500 r.p.m., and a full-load fuel consumption of 7000 B.Th.U. per brake horsepower per hour. Three, four, five, six, seven and eight-cylinder models are available having a twelve-hour brake horsepower rating of 390, 520, 650, 780, 910 and 1040 b.h.p. respectively. The bore and stroke of the B2AUG engines are 17in and 21½in respectively and the full-load brake mean effective pressure is 121·5 lb per square inch, while the maximum governed speed is 333 r.p.m. and the full-load fuel consumption 7000 B.Th.U. per brake horsepower per hour. These engines are available with five, six, seven and eight cylinders having a corresponding twelve-hour brake horsepower rating of 1250, 1500, 1750 and 2000 b.h.p.

In addition to the above spark ignition supercharged gas engines the same marks of engine have been developed using a pilot injection of fuel oil as a means of ignition, so that the "F" and "B" series are available as supercharged gas engines with spark ignition, as supercharged gas engines with pilot fuel ignition and alternative fuel engines which can run as straight oil engines or as spark ignition or pilot fuel ignition by means of an adjusting lever while the engine is running.

During the course of a recent visit to see these

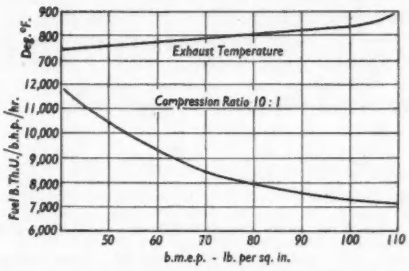


Fig. 4—F2AUG Single-Cylinder Experimental Engine Performance on Town's Gas

developments in pressure-charged gas engines, the opportunity was taken to make a brief tour of the works, which are, at present, in the middle of a large reorganisation programme. This programme calls for a complete change-over of the work normally carried out in a number of shops and the resiting of machines to suit the new operation schedules and the production flow. The overall plan to change the emphasis of production is the result of the company's scheme to meet the changing pattern of world demand for power units and to combat the effects of the changed conditions of trade caused by restrictions imposed by a number of countries. Horizontal oil engine production, which formed a large proportion of the turnover in 1952, was mainly affected and was reduced to a negligible amount. To counteract this recession in the demand for horizontal gas engines, production is being concentrated on the building of vertical engines, and to this end there has been a regrouping of machines to enable the works to produce engines efficiently and to fit in with the new scheme of production. Machines are being moved from their old to their new positions at the rate of about thirty per week, and the company expect to have completed the change-over by the end of the year.

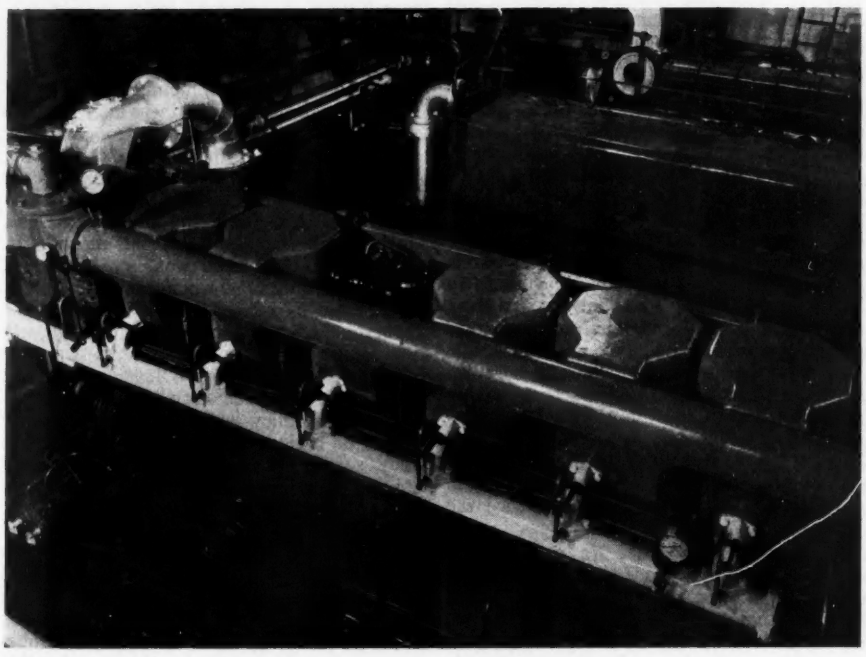


Fig. 3—Supercharged Gas Engine

Rigid Plastic Industrial Sheet

We have received from Bakelite, Ltd., some notes on a typical industrial application of its recently introduced "Vybak VR 215" rigid plastic industrial sheet, which is based upon polyvinyl chloride. The material is now being used largely on the construction of a range of centrifugal exhaust fans and ducting for use in chemical plants or other places where corrosive fumes are present. These fans are made by Turner and Brown, Ltd., of Bolton, in capacities ranging from 300 to 15,000 cubic feet per minute.

The plastic industrial sheet, which has a high impact and tensile strength, good dimensional stability and strongly resists chemical attack, is used for the construction of the casings, impellers and impeller shafts of the fans. The fan casing is bolted to an outside frame of metal, and as the outlet can be arranged in any one of sixteen positions, a fan unit can be easily coupled to existing ducting or fitted in restricted spaces. A twelve-bladed impeller is mounted on a boss of the same material and a hollow shaft for the introduction of the keyed steel shaft of the motor.

We are informed that "Vybak" sheet can be machined and fabricated by methods similar to those used for sheet metals. It can be formed to a required contour by heating above its softening point and cooling in contact with a former. To join parts made of the plastic it is "hot gas" welded with a matching rod. As the material is thermoplastic, it requires support when used for equipment operating at temperatures above 60 deg. Cent., but below this temperature it is quite inert.

Creep Properties of Steel

INSTITUTION OF MECHANICAL ENGINEERS

At a meeting of the Institution of Mechanical Engineers last Friday, December 4th, the following papers were presented and discussed :—

COMPARATIVE HIGH-TEMPERATURE PROPERTIES OF BRITISH AND AMERICAN STEELS

By W. E. BARDGETT, B.Sc. (A.M.I.Mech.E.),* and Dr. C. L. CLARK†

SYNOPSIS

Some rather substantial differences are found in creep data on similar steels published in various countries. In view of the importance of these differences in relation to design stresses, arrangements were made for an exchange of specimens between the Timken Roller Bearing Company, of Ohio, and the United Steel Companies in order to determine whether the results from the two laboratories, on the same steel, would be in agreement, and to compare the creep resistance of selected steels. Five representative high-temperature steels were chosen, comprising three commonly used ferritic steels and two austenitic steels. For each composition, four creep curves were obtained, two by each laboratory. Stress, temperature, and time adopted in the tests in the two laboratories were the same and no attempt was made at standardisation of test procedure. A high degree of reproducibility was shown by the test results for the two laboratories on the ferritic steels, but those on the austenitic steels showed generally substantial differences. Only two British steels, both ferritic, showed similar creep behaviour compared with the corresponding American steels, the remaining three steels showing appreciable differences, which are discussed.

A CRITICAL EXAMINATION OF PROCEDURES USED IN BRITAIN AND THE UNITED STATES TO DETERMINE CREEP STRESSES FOR THE DESIGN OF POWER PLANT FOR LONG LIFE AT HIGH TEMPERATURES

By R. W. BAILEY, D.Sc. (Eng.), Wh.Sc. (Vice-President), F.R.S.‡

SYNOPSIS

The operating life of land power plant being far longer than allowable testing times for the constructional metals, the selection of a material, or the determination of its appropriate working stress, is dependent in an important degree upon the procedure followed in utilising the creep test results obtained. Different procedures practised both in Britain and in the United States can result in different views regarding the potentialities of a material, and also about the working stress allowable. The paper examines the more commonly used procedures and focuses attention upon the factors present which would operate to introduce uncertainty and error as between the probable behaviour in the long time of actual service, and as yielded by a test procedure.

The principal disturbing factor in altering the resistance to creep of the material is thermal action. In some procedures, especially where the creep tests are made at working temperatures, the influence of this factor may be small or negligible in the procedure, compared with its magnitude in service. The need is emphasised for thermal action to be taken adequately into account by the test procedure. Next in importance as a possible source of error is the method of extrapolation beyond the test times to the time of the operating life.

The factor of thermal action and of its representation in the several procedures examined is considered. The circumstances of extrapolation are similarly investigated, especially in regard to whether the result would overestimate or under-estimate the safe working stress.

Satisfying comparisons of working stresses using different procedures cannot at present be made. The position is therefore disappointing, and one which it is very desirable should be rectified.

DISCUSSION

Mr. L. C. Southcott said that shortly after the war, increasing attention had been given to high steam temperatures, and decisions had had to be made on the selection of materials and working stresses. In the examination of American methods, the question had then arisen as to whether steels produced in the two countries to the same nominal specification would have similar creep properties, and he wished to thank both Mr. Bardgett and Dr. Clark for so readily acting on the suggestion that an examination of some typical steels produced in both countries be carried out. It had been a privilege to follow this work during the last few years. While information regarding creep properties of steels was supplied by the various laboratories, it was the responsibility of the design engineer to use the information. He felt that some comments on this aspect might be useful in indicating the difficulties encountered in the design of commercial plant, especially when British and American companies were in competition for foreign orders. It was well to remember that the A.S.M.E. Code was incorporated in the State law of most American States and that compliance with the code was, therefore, mandatory, whereas B.S. 1113—"Water-Tube Boilers and Their Integral Superheaters"—was purely a recommended code of good practice. Further, the latter code in its present issue did not give recommendations for stresses for some of the materials used in the outlet stages of high-temperature superheaters and in steam piping. Therefore, if materials other than mild steel, 0·5 per cent molybdenum steel and 1 per cent chrome, 0·5 per cent molybdenum steel were used, the British designer must put forward his recommendations for working stresses without reference to B.S. 1113.

In steam piping the actual working conditions as regards pressure and temperature were established, but in superheater tubes, whilst the pressure was known, considerable variations did take place in metal temperature even with those designs incorporating controlled final steam temperature. In piping only a small extension in diameter due to creep in the lifetime of the pipe was considered safe, but in the case of superheater tubes, provided fracture did not occur, increase in diameter was of secondary importance. Further, failure of superheater tubes did not in practice involve danger to life, however inconvenient the subsequent boiler outage might be. In selecting the working stress for superheater tubes there were at least two possible methods. It might be assumed that there was perfect uniformity at all times, both on the steam and gas side of the tubing, and that their knowledge of heat transfer was sufficiently accurate for the working metal temperature to be established under such conditions. If, then, a stress corresponding to only a low rate of creep was employed, a considerable factor of safety was provided, and this was available to compensate for the tubes working above design temperature for part of their lifetime. Alternatively, recognising that fluctuations in metal temperature were inevitable in modern boiler plants and that even the best design and operation could only minimise the temperature band through which the tube worked, it was possible to base on stresses which would cause fracture, having first estimated the maximum metal temperatures likely to prevail. In practice, with the latter method, the duration of excess temperature periods was indeterminate. Both the A.S.M.E. Code and B.S. 1113 used the first method.

It had been proposed to establish an International Boiler Code, and if this was to be accomplished then there must be means of ensuring that steels produced in the various countries to the specifications issued in connection with that code were reasonably consistent with one another in their creep properties, and obviously agreement must also be reached on methods of interpreting creep results and selecting working stresses. It might well be that the papers now under discussion would serve as an introduction for that work. Apart from Dr. Bailey's criticisms regarding the validity of the methods in use for the extrapolation of the creep results and, therefore, the difficulty of assessing correctly the stress to give a small degree of creep in twenty or twenty-five years, it was becoming increasingly important to know with the greatest practical degree of accuracy the actual individual working temperatures of the most vulnerable sections of the superheater. Work was now in hand on gear which would give the operator that information and therefore make it possible for him to adhere more closely to the design temperature than had been the case up to the present.

Dr. N. P. Allen said that the difficulty of forecasting the creep behaviour of a material was a very real one, because there was real uncertainty whether the processes which had been going on in the metal during short periods of test would continue unchanged over longer times. For this reason, no mathematical treatment of the results of short-time tests could produce a certain result. Most creep-resisting materials now used consisted of a crystalline matrix through which very fine hard particles were distributed. The particles were formed by precipitation from solution in the matrix; they were commonly being precipitated or growing in size whilst the alloy was in service, and alloys were chosen in which the precipitates grew extremely slowly. The laws governing the processes had been extensively studied over past years. The rate of precipitation did not vary uniformly with temperature. Commonly there was a fairly sharply defined range of temperature in which the rate of formation was a maximum, and commonly the nature of the precipitate altered when the temperature changed. A precipitate *A* might have a very different effect upon the mechanical properties from that of a precipitate *B*. Below a certain temperature only *B* might form no matter how long the test was made; above that temperature, only *A*. Moreover, the rate of formation was not uniform. In some cases the precipitate began to form at once and soon reached a stable condition. In other cases, there was a long "period of induction"—it might be hundreds of hours—before the change started. Sometimes one kind of precipitate formed first and was later replaced by another.

Dr. Bailey's main thesis was that in trying to accelerate the changes that took place it was better to raise the temperature than to raise the stress. Lumping all these possible changes together as "thermal effect," Dr. Bailey said that there was no increase of "thermal effect" when the test was accelerated by increased stress, and that the "thermal effect" increased uniformly with temperature rises according to the Maxwell-Boltzmann relation ($T=Ae^{E/kT}$) and was susceptible to calculation. In both these points Dr. Bailey would, he was afraid, be found on a close examination to be wrong; they simply were not true. It was well known that the rates at which these changes took place were often much increased by the plastic deformation resulting from increased stress, often in quite as striking a way as by increased temperature. He had already said that the rates of change were not always increased by raising the temperature, and even in the cases where the Maxwell-Boltzmann relation applied, the acceleration energy *E* was not necessarily unchanged by

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† Metallurgical engineer, the Timken Roller Bearing Company, steel and tube division, Ohio.

‡ Consulting research engineer, Metropolitan-Vickers Electrical Company, Ltd.

change of temperature, and, in general, one did not know what it was.

He thought that one could very well sympathise with Dr. Bailey's final conclusion—that one must understand the material and its thermal effect in order to make these extrapolations rightly. He would say that engineers generally did not quite appreciate as much as they should the importance of knowing what these changes were that took place in the material as a result of heating. The second thing that arose was that, provided the material was well understood in its metallography, then the testing procedure and the extrapolation methods as well were sufficiently good to be the least of the uncertainties in all this problem. Considering that the stress could be got accurately within 20 per cent and the temperature within 10 deg. Cent., with extrapolation of 10 to 100,000, he asked who (in view of what the last speaker had said) was going to say that he knew the temperature of a material within 10 deg. Cent. and what engineer was going to say that he knew the stress in every part of the component to 20 per cent, and who knew how long the power station was actually going to last ? Was it going to be wanted for eight or for twenty years ? The other uncertainty was that people did not know what was the magnitude of the extension that was really required. Some people said that the component would work satisfactorily up to 0·1 per cent extension, others were prepared to accept 0·5 per cent, and that made an enormous difference. So he thought that one could over-estimate the uncertainty due to the unsatisfactoriness of the testing methods. If the material were known and those methods were carefully applied, he thought there was a good deal more certainty in that part of the situation than in most other aspects of it.

Mr. P. H. Margen felt that Dr. Bailey's paper had been built around the term "thermal action." But really one should distinguish between two different hypotheses made in connection with that term. The first hypothesis was that by a given amount of preheating one could simulate long-term conditions. Again, as Dr. Allen had mentioned, the trouble was that one did not know what the relation was, and until one did know the experimental relation for each particular steel (and Dr. Bailey's own evidence suggested that it differed for each) one could not use that method for accelerating tests and for substituting short-term tests for long-term tests just by having a bit more of preheating. The second hypothesis was that (this was quite distinct from the first one) if data were plotted as log-stress log-time curves, one obtained graphs which had a curvature and might have an even more pronounced curvature outside the test range, and therefore were very difficult to extrapolate ; whereas, if one plotted the data as temperature log-time curves, there was not such a tendency for curvature. The author had only shown five plots, some for each type being curved. So he did not think the author had really established his case. Having himself examined something like thirty lines of each type, he had found that quite a lot of them did have a curvature ; so he thought that both hypotheses were dangerous.

Dr. Bailey had recommended that all working stresses should always be based on creep-strain data and not on rupture data. Obviously for precision components one had to have creep-strain data, but for non-precision components where one was not interested in the deformation but only in the component standing up to the stress without fracture—and he would put the steam pipe in that class, although a previous speaker had not thought so—surely, for that type of component, it was the rupture stress which was really valid. He submitted that for all non-precision components one should use rupture data with a carefully selected safety factor, and for all precision components one should at least check that the rupture stress safety margin was sufficient, and in deriving a rupture stress safety factor one should use statistical methods to allow for the various factors of uncertainty which Dr. Allen had mentioned.

Mr. J. Glen (Motherwell) said that the paper by Dr. Bailey provided much food for thought and covered so much ground that it was only possible to discuss a few aspects of the subject. His first question related to the equation $dx/dt = Af^n x^{-p}$. It was stated that with an unchanging material A, n and p were treated as constants, although their value would be different for the primary, secondary and tertiary stages of creep. A and p derived from creep curves varied, depending on the stress and temperature, while the power n of the stress also varied with stress as well as temperature. It was not clear to him, moreover, why the constant A should embrace all the thermal action effect. If so, what evidence was there to substantiate the statement that the thermal action had a negligible effect on the values of n and p ? Perhaps Dr. Bailey could expand his explanation of this equation, since it virtually formed the basis of the paper.

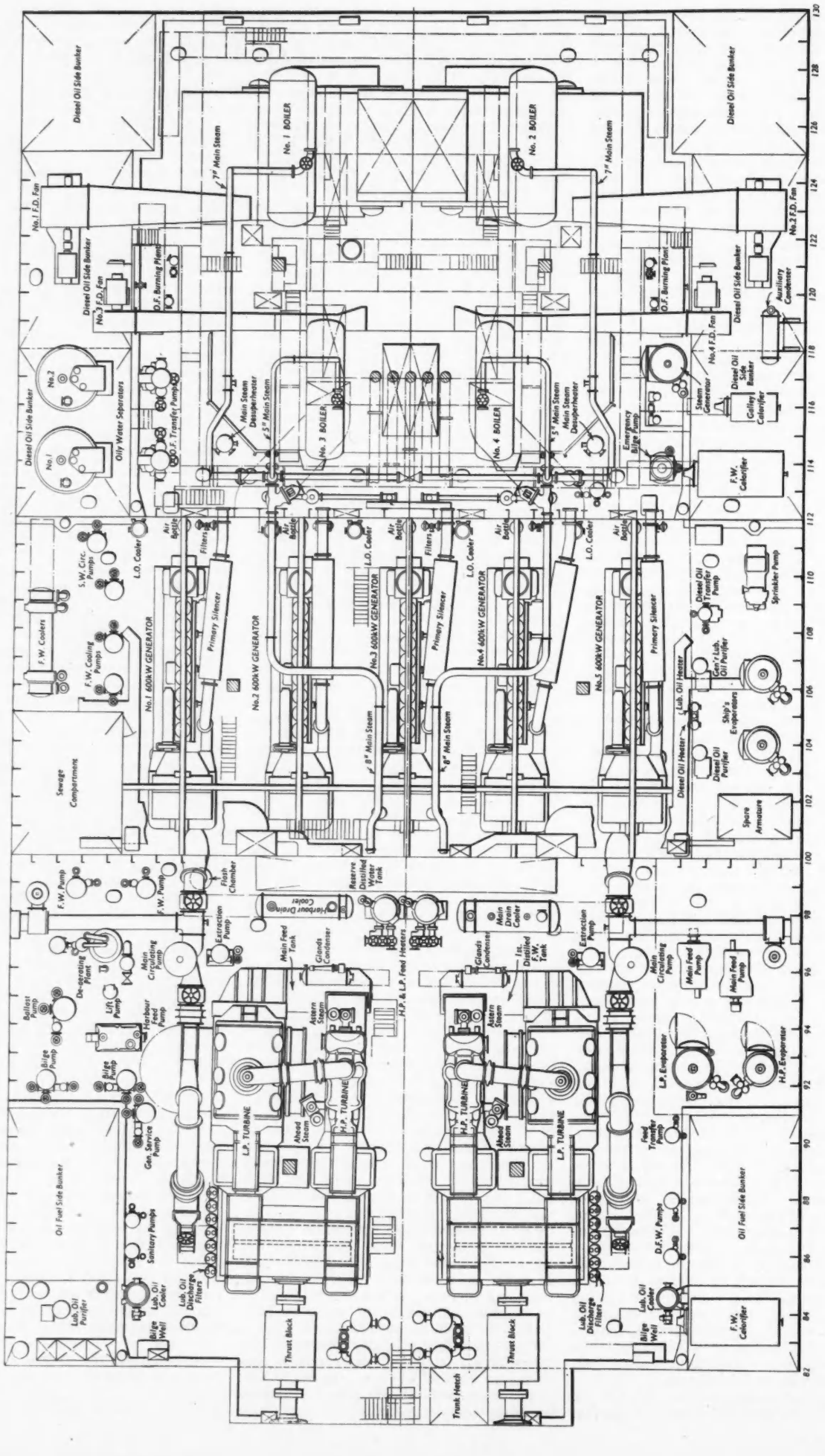
In dealing with creep tests at constant stress and varying temperature, Dr. Bailey, in an appendix, had elaborated this procedure in order to take into consideration the effect of thermal action. The necessity for this was based on Dr. Bailey's conclusion that the higher the testing temperature the smaller was the amount of thermal action during the time taken at the testing temperature to reach a specified creep strain. It was possible to investigate whether or not this conclusion was correct by carrying out creep tests on the same steel in two conditions of heat-treatment. A 0·5 per cent molybdenum steel had been tested in two conditions, namely, normalised and normalised+tempered for ten hours at 650 deg. Cent. Ten hours' tempering gave the maximum stiffening effect of thermal action in a creep test such as that shown in Fig. 13 of the paper. Thermal action, it was found, had a different effect depending on the stress and temperature of testing, in general the tempered steel being the better the lower the stress and/or the lower the temperature of testing. If thermal action had a lesser effect with increased temperature of testing, as Dr. Bailey suggested, the tempered steel should be the better above a certain temperature, and worse below that temperature. In fact, the opposite seemed to be the true picture. It might be argued that the effect of thermal action during the actual creep tests had not been fully taken into consideration. Even if this were correct, it could be argued that, since at constant temperature the time to reach 0·1 deformation would increase as the stress decreased, and since ten hours' tempering was supposed to give the maximum stiffening, then at constant temperature the tempered steel should become the worse as the stress of testing was decreased, whereas in fact it became the best. It could be concluded, therefore, that at operating temperatures and stresses the effect of thermal action was not nearly so deleterious as might be supposed on the basis of short-time tests at a higher stress and/or temperature. It might, indeed, be advantageous. It was obvious, therefore, that much more work required to be done to elucidate completely the effect of thermal action on the creep strength. At present there remained an element of doubt in any particular case, which could only be removed by carrying out very long-time tests.

Mr. H. W. Kirkby (Sheffield) showed nine slides giving the curves produced in tests which he had carried out on various steels.

Dr. J. M. Robertson said that in order to discover from tests of short duration what was likely to occur under service conditions of long duration, it was required, by the methods practised in this country, to produce in the tests amounts of creep that were similar to those likely to occur in service. This could be done by doing the tests at the service temperature and raising the stress above that which would be applied in service. This was the method generally used. Alternatively, the tests might be done under the stress that it was proposed to use in service and the temperature raised to accelerate creep. This was the method advocated by Dr. Bailey, who pointed out that little testing had been done in this way over and above that sponsored by a committee on which his views had a great deal of weight. It should be added, however, that the work done by that committee had, in turn, a great deal of weight in relation to the use of materials in steam plant. If tests were done at the service temperature and creep was accelerated by raising the stress, an amount of creep that would take a long time to occur in service might be obtained in a much shorter time in the tests, but the structural and constitutional changes that could occur during the long time in service would not occur during the test. If, on the other hand, the tests were done under a constant stress and creep was accelerated by raising the temperature, the constitutional and structural changes that affected the properties were also accelerated. It was because of this that Dr. Bailey had considered the latter method to be more reliable than the former, and the question arose why so many people preferred to accelerate creep by raising the stress instead of by raising the temperature. One reason for this appeared to be that one of the first things that was decided with regard to any kind of high-temperature plant was the temperature that would prevail at different parts of the plant. In designing components and selecting materials, information about the stress that could be applied at a known temperature was more convenient than information about the temperature that might be used with a known stress. Furthermore, when creep was accelerated by raising the temperature, it appeared that if two steels A and B had similar properties at, say, 1100 deg. Fah., and A was better than B at 1200 deg. Fah., then B might seem better than A when the result was extrapolated to 1000 deg. Fah. It was difficult to believe that this was necessarily so. Finally, it appeared that results obtained by raising the stress agreed more closely with straight line extrapolation on the basis of the log of time than time obtained by raising the temperature. From a metallurgical standpoint, Dr. Bailey's views on the importance of taking thermal action into account were very sound provided that the increased temperature did accelerate a constructional or constitutional change that took place more slowly at the service temperature, did not promote any changes that would not take place at the service temperature, and did not lead to surface reactions such as oxidation or decarburisation that reduced the creep resistance.

In studying the properties of carbon, carbon-molybdenum and chromium-molybdenum steels used in the normalised condition, it could be assumed that raising the

MACHINERY OF GREEK LINE STEAMSHIP "OLYMPIA"



test temperatures above the service temperature would do no more than accelerate the spheroidisation of carbide, but the position was not so simple when one came to deal with the three types of steel on which interest was now being centred, namely, the low-alloy ferritic steels in which molybdenum and vanadium were essential elements, and in which various amounts of chromium might also be present ; the high-chromium ferritic steels which contained in addition various combinations of molybdenum, titanium, vanadium and niobium, and the complex creep-resisting austenitic steels. With all those steels the creep resistance was improved by a tempering treatment (which also served as a precipitation treatment) after the normalising, hardening or softening treatment (which also served as a solution treatment). When the tempering treatment was carried out for a substantial time at a temperature well above the service temperature, it was open to question whether any significant constitutional or structural changes would take place at the service temperature, and whatever the relations between the tempering and service temperatures there was always the possibility, with steels in which complex changes could occur, that raising the test temperature well above the service temperature would promote changes that would not occur in service at all.

It was not easy to find results of tests of about 10,000 hours' duration that enabled the two methods of accelerating creep to be compared. He had been able to do this for one material, however, and had found that the stress-temperature conditions for 0·1 per cent of creep and for fracture in 100,000 hours obtained by extrapolating the results obtained by raising the temperature had been more favourable to the material than those obtained by raising the stress. This was contrary to what Dr. Bailey would expect.

Mr. H. J. J. Redwood said that there was some evidence to support the suggestion in the paper by Mr. Bardgett and Dr. Clark that the difference in the results from the T.R.B. and U.S.C. steels of the 18 per cent chromium—12 per cent nickel and columbium type might be due to the high stress used for the tests.

The authors replied shortly and the meeting ended.

Greek Line Steamship "Olympia"

No. II—(*Concluded from page* 728, *December* 4*th*)

In October the steamship "Olympia" sailed on her maiden voyage in the service of the Greek Line between Bremerhaven and New York. The ship is mainly designed to carry tourist-class passengers and is propelled at a service speed of 21 *knots by twin screws. Power is provided by two sets of double reduction geared turbines developing* 24,000 *s.h.p. and taking steam at* 525 *lb per square inch pressure and* 800 *deg. Fah.*

Propelling Machinery

OUR line drawing giving a plan view of the machinery spaces shows the general arrangement of the main and auxiliary machinery, the electrical generators and the boiler plant. Two sets of double reduction geared turbines built by Alexander Stephen and Sons, Ltd., to Pametrada designs, are supplied with steam at 490 lb per square inch and 790 deg. Fah. at the turbine stop valve, and are capable of developing a total ahead power of 25,000 s.h.p. The normal ahead power of 24,000 s.h.p. at propeller revolutions of 140 r.p.m. is sufficient to give the ship a service speed of 21 knots.

Each set of turbines consists of an h.p. and l.p. turbine, the h.p. turbine having fourteen stages of impulse blading, a casing of cast steel, and incorporating a two-stage impulse h.p. astern turbine overhung at the forward end. The blading is of Hecla A.T.V. steel, mainly segmentally fitted, having chromium iron packing and side locking strips of Lowmoor iron. The double-flow l.p. turbine has fifteen stages of stainless iron reaction blading in each half and includes at the forward end of the same casing a two-stage impulse l.p. astern turbine. A two-casing design has been adopted with the outer casing being under vacuum. Built-up nozzle plates and diaphragms are fitted.

The double reduction gearing is of articulated design with fabricated steel gear wheels and nickel steel pinions, while the gearcase is of welded construction to the builders' design. This provides for separate first and second reduction cases, which are finally bolted together, in order to give easy facilities for machining and assembling. The two propellers, supplied by Bulls Metal and Marine, Ltd., are of three-bladed design and have a diameter of 18ft by a mean pitch of 17ft. The spare propeller has a cast steel boss and separate blades.

A well-equipped engineers' workshop and laboratory is located in a flat to starboard.

Boiler Plant

Steam is supplied at 525 lb per square inch and 800 deg. Fah. at the superheater by four Foster-Wheeler oil-burning water-tube boilers consisting of two four-furnace "D" pattern and two seven-furnace controlled superheat boilers, all fitted with Clyde soot blowers. The evaporation rate is 85,000 lb per hour for the latter design, which has a generating surface of 16,210 square feet and a superheater surface of 1575 square feet. For the "D" pattern units the corresponding figures are 35,000 lb per hour, 7910 square feet, and 1130 square feet respectively. All the boilers are fitted with Green's economisers, and two auxiliary steam desuperheaters of Babcock and Wilcox manufacture are fitted and can deal with 20,000 lb per hour from 800 deg. to 410 deg. Fah.

The boilers burn oil fuel under Howden's balanced system of forced draught, there being a forced draught and an induced draught fan for each boiler. For the larger boilers there are two forced draught fans, each driven by a 31 h.p. motor and delivering 30,000 cubic feet of air per minute and two induced draught fans having 91 h.p. motors and each dealing with 48,000 cubic feet of air per minute. The rating of the forced draught fans for the smaller boilers is 12,000 cubic feet per minute when driven by a 13 h.p. motor, while the induced draught fans, which are driven by 40 h.p. motors, deal with 19,500 cubic feet of air per minute. The forced draught fans are mounted on flats to port and starboard in the boiler-room, and the induced draught fans are placed at the base of the funnels.

There are two sets of Wallsend oil fuel burning installations, each having a capacity of 21,000 lb per hour at 300 lb per square inch, and two 80 tons per hour oil fuel transfer pumps of Weir's manufacture. "Alfloc" injection plant for the treatment of boiler feed water is provided, together with chemical testing equipment, and there are low-water alarms, high-level water cut-off gear, and CO_2 recorders. The builders' own arrangement for the remote control of oil fuel valves is fitted and also a hand-operated hydraulic lifting gear for the engine-room skylight.

Closed Feed System

The ship is equipped with Weir regenerative condensers and closed feed system, the condensers, which are de-aerating and have an area of 6600 square feet, being slung under the l.p. turbine and spring supported. All make-up to the feed system passes through a closed feed controller and is sprayed into the steam lane in the condenser so that it is de-aerated before joining the main condensate, while surplus water is discharged to the main feed tank and any shortage is made up by water passing from the feed tank to the condenser through the controller.

The system consists of two two-stage vertical extraction pumps, each driven by a 30 h.p. motor and delivering 125,000 lb of condensate per hour to two three-stage "Maxivac" air ejectors, each dealing with 40 lb of air associated with 24 lb of vapour per hour, and thence through two glands condensers of 750 lb per hour capacity. After passing through the four-flow drain cooler the condensate is returned to the boilers by two main turbo-feed pumps, each having a normal capacity of 325,000 lb per hour against a discharge pressure of 750 lb per square inch gauge and taking steam at 490 lb per square inch gauge and 800 deg. Fah. The temperature of the feed water is raised from 129 deg. to 185 deg. Fah. in a four-flow, low-pressure bled steam heater at the rate of 210,000 lb per hour and is then raised to 240 deg. Fah. in a high-pressure bled steam heater of similar capacity. From the heater the feed water is discharged through economisers into the boilers and the quantity entering is controlled by a "Robot" boiler feed regulator.

For harbour duties there is an "Optimum" de-aerating plant which can handle 28,850 lb per hour, A single-stage supply pump discharges water to the de-aerator and a two-stage extraction pump delivers at the rate of 28,850 lb per hour to the two-stage harbour turbo-feed pump, which has a capacity of 52,000 lb per hour against a discharge pressure of 750 lb per square inch gauge. Make-up water to the boiler system is provided by a low-pressure evaporator having a capacity of 40 tons per day, while for harbour use there is an evaporator of 50 tons per day capacity and a distiller. For domestic purposes, two evaporators have been supplied, each producing 50 tons per day. In addition to the above, G. and J. Weir, Ltd., has supplied a steam-to-steam generator, with a capacity of 5000 lb per hour at 100 lb per square inch, and an associated feed pump for supplying steam to the fuel heaters.

Auxiliaries

Apart from the turbine-driven feed pumps the auxiliaries are generally electrically driven, nearly all the motors being supplied by W. H. Allen, Sons and Co., Ltd., while the pumps, except those for particular services, were provided by Drysdale and Co., Ltd. These include one general service and two bilge pumps capable of delivering 140 tons per hour against a 70ft head ; two sanitary pumps of 30 tons per hour capacity against a head of 150ft ; two main circulating pumps with a capacity of 11,500 gallons per minute against a 23ft head; one of 200 tons per hour capacity against 70ft head ballast pump ; a stokehold bilge pump of 30 tons per hour capacity, and an emergency bilge pump to deliver 140 tons per hour against a 75ft head.

The lubricating oil system includes a heater and a purifier, each of 300 gallons per hour capacity, supplied by Alfa Laval Company, Ltd., Vokes filters, two 20,000 gallons per hour Serck coolers and four Drysdale pumps delivering 20,000 gallons per hour at 45 lb per square inch. For controlling the ship's fresh water supply the Drysdale "Pneupress" system is installed, there being two fresh water calorifiers and one galley calorifier, and two 80 tons per hour "Comyn" oily water separators. Three separate sewage disposal systems, supplied by Adams Hydraulics, Ltd., are fitted; one is placed in a compartment in the shaft tunnel space, another is located to port in the generator room, and the third is installed in a compartment forward of the boiler-room. J. and E. Hall, Ltd., supplied the refrigeration machinery, which is situated on "D" deck aft of the engine-room, and is a "Freon 12" unit of a capacity suitable for dealing with the ship's stores and ready-use cupboards and for maintaining 7400 cubic feet of cargo space at 15 deg. Fah.

The electrical power for the auxiliary machinery, heating, lighting, cooking and other ship's services is provided by five Allen 600kW generators, each driven by an eight-cylinder

British Polar diesel engine developing 920 h.p. at 425 r.p.m. Each generator set has an associated air bottle and Serck lubricating oil cooler, and for the group there are two Serck fresh water coolers, each capable of dissipating 7,360,000 B.Th.U. per hour. The air for the bottles is supplied by oil-driven and motor-driven Hamworthy compressors, each delivering 21·5 cubic feet of air per minute. There are two Drysdale salt water and fresh water pumps, each capable of delivering 160 tons per hour at 30 lb per square inch, and Alfa Laval heaters and purifiers for both the fuel oil and the lubricating oil. For emergency lighting and power services there is a 100kW Allen generator, driven by a six-cylinder Mark M4.A6 " National " oil engine, which is placed in a compartment on the sports deck just aft of the funnel. In the adjoining room is a 220V standby " Chloride " battery, which can maintain skeleton emergency lighting until the emergency generator can be brought into operation. The main switchboard is on " B " deck, immediately above the generator room.

Ventilation of the engine-room is effected by four Musgrave fans, each having a capacity of 30,000 cubic feet per minute at 520 r.p.m. and mounted in a house on the sports deck. The ventilation of the boiler-room is provided for by a similar group of fans arranged on the sports deck at the base of the funnel. Two exhaust fans supplied by the Winsor Engineering Company, Ltd., are fitted to serve the diesel generator compartment.

Mobile Electrical Testing Laboratory

A MOBILE electrical laboratory has been equipped and taken into service by the English Electric Company, Ltd., for the investigation of transient and recurrent phenomena on site. The laboratory is designed to overcome the difficulties usually associated with this sort of work on site—particularly the lack of space for setting up oscillographic apparatus and the absence of dark-room facilities.

The laboratory consists of a specially fitted towing vehicle and trailer. To give the maximum flexibility in use the majority of the laboratory equipment is not built in. On any particular job, therefore, it is possible to select only those items of test apparatus that are likely to be required and to store the remainder of the available test equipment at the company's Stafford works.

The towing vehicle is a standard Bedford " Middleweight " chassis with a 28·9 h.p. engine, but the body was specially built to accommodate up to twelve people or to carry a load of 30 cwt. The trailer, which was built to the customer's requirements by Berkeley Coachwork, Ltd., Biggleswade, Beds, is 20ft long by 7ft 3in wide by 9ft high. It weighs 40 cwt unloaded and can carry up to 30 cwt of test equipment. The two-wheeled trailer is equipped with pneumatic brakes, which can be operated from the towing vehicle, to give greater control downhill and on corners. The overall length of the trailer and towing vehicle is 41ft.

The laboratory is intended to facilitate the study and recording of transient and recurrent phenomena on electrical machinery and switchgear made by the company. Measurements and analysis can be made of noise and vibrations and there is provision for high-voltage testing. Among the special items of equipment for the laboratory are cathode-ray and Duddell oscillographs and a high-voltage test set. With the oscillographs up to six traces can be measured and recorded simultaneously on continuous drum and roll films, which can then be processed in the dark-room, the entrance to which can be seen in one of the accompanying illustrations. The photographic equipment carried in the trailer includes a quarter plate camera, a 16mm ciné camera taking up to sixty-four frames per second, and a manually operated projector, whereby individual frames of the ciné film can be viewed on a ground glass screen.

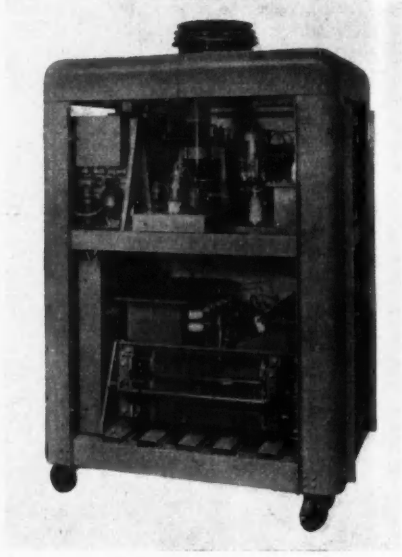
At the rear end of the trailer, as shown in our first illustration, there is a workbench with cupboard and drawers for storing the smaller items of equipment, including meters test leads and tools. The larger pieces of apparatus are strapped to channel sections in the roof and walls.

Electric power supplies are normally available on site and sufficient cable is carried in the trailer to provide the necessary connection. The supply cable is stored with an earthing cable and water hose, under the workbench at the back of the trailer. The earthing cable can be run out on site and connected either to the equipment under study or to any other convenient earth. In the trailer the end of the earthing cable is connected to a copper strip, whereby an earth connection can be made with the test apparatus.

Water for use in the dark-room is contained in two tanks under the trailer floor and is electrically pumped to the taps above a sink. Normally the tanks are filled from the local water mains, through the length of hose carried in the back of the trailer. If, however, prolonged tests are to be carried out at a site where the water cannot be replenished, the film washing water can be drained back from the sink into one of the water tanks and can then be used again. An electric water heater is installed. Thermostatically controlled electric heaters, as shown in one of our illustrations, are fitted in the trailer for the comfort of the test staff and for counteracting condensation in humid atmospheres.

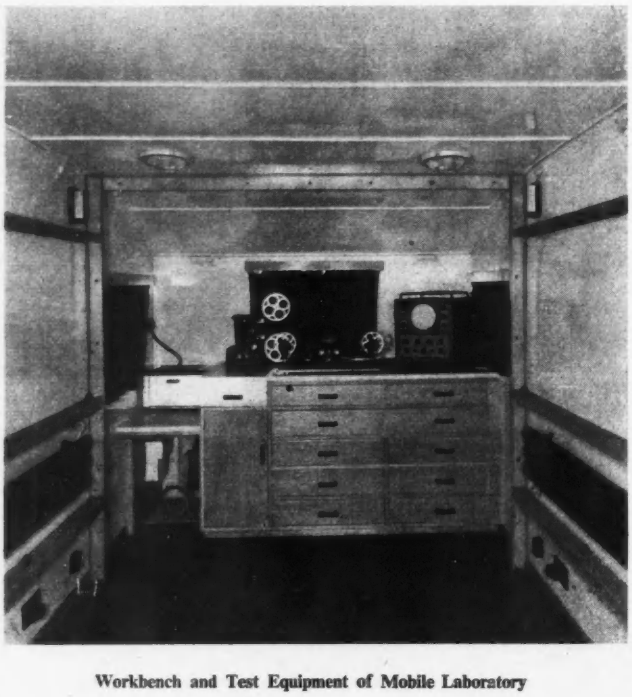
High-Power Pulse Modulator

A HIGH-POWER pulse modulator for generating microsecond pulses of high energy for operating magnetrons has been developed by Mullard, Ltd., Century House, Shaftesbury Avenue, London, W.C.2. It is based on a design evolved for use with linear accelerators, but it is suitable for other applications, such as testing magnetrons or operating very high power radar ground stations.

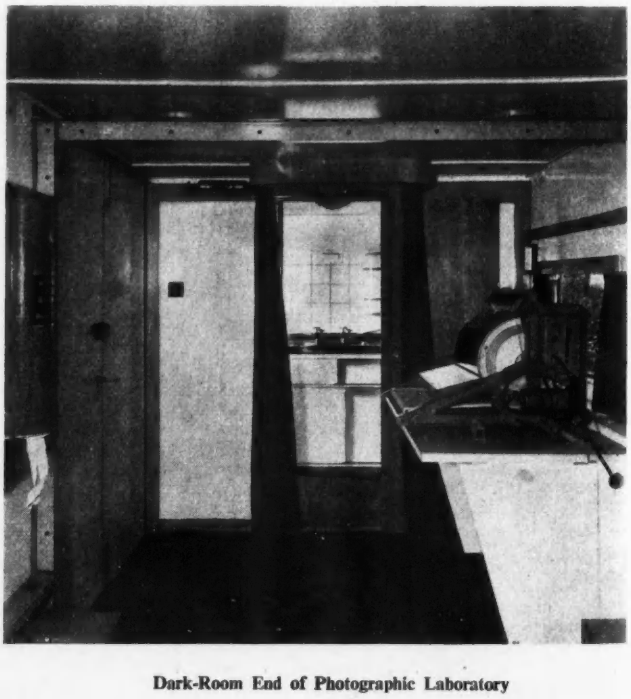


Modulator with Back Cover Removed

In its normal form the modulator generates two-microsecond pulses with a peak power of 5 megawatts. Other pulse lengths may be obtained by using alternative delay lines. Pulses for triggering the modulator are provided internally by a generator which gives p.r.f. (pulse repetition frequencies) of 100, 200, 350 and 500



Workbench and Test Equipment of Mobile Laboratory



Dark-Room End of Photographic Laboratory

pulses per second. The modulator can be triggered externally at any p.r.f. between 10 and 500 pulses per second. The output power can be varied by a single control, the actual power control mechanism being a motor-driven transformer which regulates the input to the three-phase mains transformer feeding the power rectifiers. The d.c. supply thus obtained can be varied between 6kV and 12kV. A magnetron filament supply of 9A at 18V is built into the modulator.

As illustrated herewith, the equipment consists of two units—a control desk, 4ft 6in high, and the modulator itself, which is housed in a cabinet 4ft 6in wide by 3ft 6in deep by 6ft 6in high, including the castors and an extractor fan on the roof.

The usual interlocks are included to protect personnel from shock and protection is provided against failure of the magnetron field, the magnetron filament and the cooling water supply

Control Desk of Modulator

to the modulator. Facilities are also available for interlocking the associated equipment (for example, the vacuum systems) with the operation of the modulator.

The equipment is largely self checking with regard to faulty operation. Red and green lights show the state of the interlocks, a red light signifying a fault. If an overload occurs in the three-phase input, main h.t. or drive circuits, the appropriate protective relay operates and disconnects the supply.

To supplement the information given by the various indicating meters there is a built-in oscilloscope which provides five standard circuit checks, the time base being triggered by the p.r.f. unit. Spare switch positions permit the monitoring of miscellaneous external currents or voltages and the connection of a 60 dB amplifier. For these purposes the time base can be triggered externally.

Air Turbine Accessory Drive Units

THE existing method of driving aircraft alternators and generators by a shaft coupled to the main engine, despite its simplicity, has, amongst its more serious limitations, the inability to drive the accessories at a constant speed and the lack of freedom in their positioning. These difficulties can be readily overcome in aircraft fitted with gas turbines by using an air turbine motor suitably governed, which is driven by a tapping from the main engine compressor through variable orifice nozzles. Thus, a constant speed drive is realised irrespective of the main engine operating condition. The alternator output can be maintained at a constant frequency with the resultant simplification of the aircraft electrical system and when a number of separate alternators have to be driven independently, the constant speed characteristic permits these to operate in parallel.

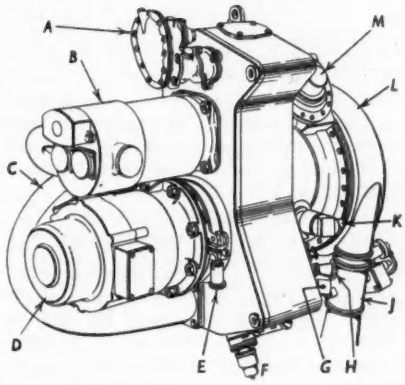
By replacing the mechanically driven auxiliary drive shaft by air ducting, the turbine unit is not only relatively easier to install in the aircraft, but in many cases, a lighter installation is achieved.

In connection with this development we learn that Rotol, Ltd., is developing a range of air turbine accessory drive units as an adjunct to its accessory drive equipment activities, and has recently concluded a licence agreement with the "AiResearch" Division of the Garrett Corporation in the United States.

The agreement will allow Rotol, Ltd., to utilise the proved technique of "AiResearch" in its design and development programme. For its first installation, Rotol, Ltd., is producing an air turbine driven accessory gearbox operating a 15kVA alternator, a 3kW generator and a fan, the latter cooling the gearbox lubrication as well as the electrical accessories.

In this installation the air turbine motor is maintained at a constant speed by means of a pneumatically operated governor system. It comprises a speed sensing device which is connected to a servo actuator. The actuator adjusts the air flow to the turbine by moving variable-area nozzles to the desired setting for maintaining constant revolutions per minute.

Variable-area nozzles are an attractive detail of the design, since high turbine efficiencies can be maintained irrespective of the condition of the air supply from the engine. The governing system is so arranged that a high degree of stability is achieved. As a safety measure, an overspeed cut-out is provided should there be any malfunctioning to cause over speeding.



A—Governor.
B—Generator.
C—Cooling duct.
D—Alternator.
E—Quick-release coupling.
F—Oil sump drain.
G—Pressure filling connection.
H—Overflow connection.
J—Air shut-off and pressure regulating valve.
K—Overspeed cut-out switch.
L—Air turbine motor.
M—Actuator.

Air Turbine Accessory Drive Unit

The various drives are pressure lubricated from a pump in the gearbox sump. An oil cooler is provided as an integral part of the sump, the oil level of which is determined by a dipstick. The usual filling, overflow and drain plugs are also provided. A centrifugal breather is fitted to prevent gearbox pressurisation and arrangements have been made to cater for negative "g" conditions.

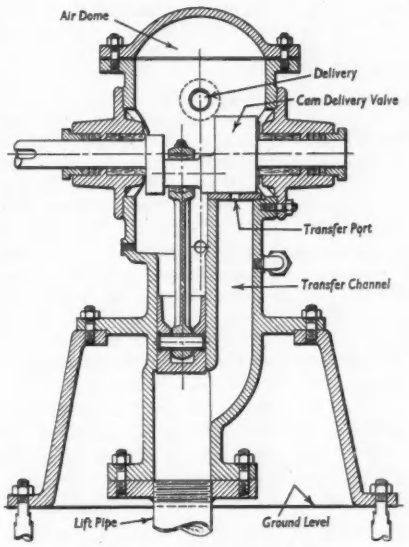
For starting and stopping the turbine, an air valve is fitted to the turbine inlet. This valve is electrically operated. In addition, it also serves as an automatic pressure regulating valve, the purpose of which is to limit the pressure of the air supply to the turbine when the aircraft is operating at low altitudes.

The company is also proceeding with further air turbine motor designs which are based on the "AiResearch" principle.

Deep Well Pump

A DEEP well pump of simple construction now being made by Gilbert Gilkes and Gordon, Ltd., Kendal, depends for its operation on the fact that water is slightly compressible. It can be arranged for deliveries ranging from 60 to 600 gallons a minute, a maximum lift of 200ft and a maximum delivery head of 100ft. All the main working parts of the pump are set on ground level and no rods or other moving parts other than a foot valve in the lift pipe are required in the well bore. The operating speed can be from 240 to 600 r.p.m. and any convenient form of drive can be adapted for the pump.

The design of the pump and its principle of operation can be followed with reference to the drawing we reproduce below. The pump body of close-grained cast iron is carried on a mounting stool and the foot of its centrally disposed cylinder is coupled through a flange directly on



Arrangement of Deep Well Pump

to the top of the lift pipe. A gunmetal piston is reciprocated in the cylinder by an alloy cast iron crankshaft which runs in water lubricated plastic bearings. Formed integrally on the crankshaft is a delivery valve with a cam profile. This valve, as it rotates with the shaft, opens and closes a port at the top of a transfer channel at the side of the cylinder.

In operation whilst the piston is moving down the cylinder the port between the transfer channel and the air dome is sealed by the valve. During this downward movement of the piston the water in the lift pipe is prevented from escaping by the foot valve and is compressed. When the piston up-stroke begins the cam valve uncovers the delivery port and releases the column of compressed water to flow up the transfer channel. The whole column of water in the lift pipe jumps up and allows a fresh supply of water to flow in from the well through the foot valve. At the same time, a similar volume of water is delivered from the pump into the rising main coupled to the air dome.

Dams Construction in Austria

AUSTRIA has important hydro-electric resources, the development of which is progressing satisfactorily, the total output of electric energy having increased from 2800 million kWh in 1938 to 8000 million kWh in 1952. The latter figure, however, represents only one-sixth of the total resources available in the country. Since 1938 twenty-one dams have been erected, three of which have heights exceeding 300ft. Amongst these dams the following are the more important: the Silvretta gravity dam; the Bieler dam, containing some 540,000 cubic yards of structural materials; the Gerlos arch dam; the Salza dam, 170ft high; the Hierzmann dam, 190ft high; the Stuibenbachtal dam, 270ft high; the arch dam of Limberg, 390ft high and 1150ft long; the gravity dams of Mooser and Drossen, respectively 350ft and 380ft high and 1540ft and 1140ft long.

THE ENGINEER

Vol. 196 DECEMBER 11, 1953 No. 5107

LEADING ARTICLES—
Shortage of Naval Engineer Officers ... 774
Cornish Engines ... 774

ARTICLES—
Air Compressors. (Illus.) ... 785
Air Turbine Accessory Drive Units. (Illus.) ... 773
Automatic Oil Burners. (Illus.) ... 783
British Steel Founders' Association ... 757
Corrosion Voltmeter ... 786
Creep Properties of Steel ... 768
Dams Construction in Austria ... 773
Deep Well Pump. (Illus.) ... 773
East Coast Sea Defence Works. No. II. (Illus.) ... 758
Engineers' Guild ... 757
Greek Line Steamship "Olympia." No. II. (Illus.) ... 771
High Power Pulse Modulator. (Illus.) ... 772
High-Pressure Turbo-Supercharger ... 779
High-Speed Grinding Spindle. (Illus.) ... 783
Iron and Steel Institute. No. II ... 777
Locomotive Valve Gears. (Illus.) ... 762
Mobile Electric Testing Laboratory. (Illus.) ... 772
National Physical Laboratory Interferometer. (Illus.) ... 763
Plate Girder Bridges. (Illus.) ... 786
Pneumatic Pressure Transmitter. (Illus.) ... 784
Polythene-Insulated 11kV Power Cable. (Illus.) 784
Power Shovel and Loader. (Illus.) ... 785
Reinforced Concrete Association ... 757
Report of the Committee on Air Pollution ... 757
Rigid Industrial Plastic Sheet ... 767
Shortage of Mathematics and Science Teachers 757
Small Chrome Plating Barrel. (Illus.) ... 786
Smithfield Show and Agricultural Machinery Exhibition. No. II. (Illus.) ... 781
Statement on Road Expenditure ... 776
Supercharged Gas Engine. (Illus.) ... 766
Timber Storage Shed. (Illus.) ... 783

LETTERS TO THE EDITOR—
Locomotive Testing at Swindon ... 775
Technical Discussion of Rocket Problems ... 776
Tidal Sluice Gates ... 776
Performance of Cars ... 776

LITERATURE ... 775
Books Received ... 777

NEWS AND NOTES—
British Patent Specifications. (Illus.) ... 791
Forthcoming Engagements ... 792
Industrial and Labour Notes ... 789
Launches and Trial Trips ... 792
Notes and Memoranda ... 790
Personal and Business ... 790
Technical Reports ... 792

SHORTAGE OF NAVAL ENGINEER OFFICERS

When announcing the Admiralty's decision on cadet entries into the Royal Navy, the First Lord emphasised that it conformed with the general trend of educational policy and was outside the field of controversy. The policy of entering all cadets in one age group at about eighteen is, in our view, sound, not only for those reasons but also on naval grounds, and because it takes account of the social changes which have taken place in recent years. It is not our purpose to comment on the shortage of entries for the Executive Branch except to suggest that if boys of the right type are to be encouraged to join the Royal Navy, there must be more emphasis on the Nelson touch and less talk about a career in little ships to defend the sea communications. We are more concerned with the shortage of engineer cadet entries, which the Dartmouth Committee reported as critical and which the common age entry at eighteen, unless other measures are taken, is unlikely to remedy. For there is no doubt that lads with an engineering bent, and their parents, are at present convinced that industry offers a better career than the Navy. That this conviction exists is evident from the serious falling-off since 1951 in the number of engineering candidates for the special or public school entry at the age of eighteen—an entry which started in 1913 and which from the outset came to be regarded as the primary source of supply of engineer officers. Further evidence is to be found in the failure of the sixteen-year-age common entry into Dartmouth (the engineering cadets after two years going on to the R.N. Engineering College, Manadon), which the Labour Government introduced in 1948. The scheme from the start failed to produce anything like the required quota of engineer officers.

Apart, however, from this widely held preference for an industrial career, many reasons are put forward why boys who are mechanically minded but want to go to sea prefer the Executive Branch. It is believed that because modern warships contain so much technical equipment executive officers must find plenty of scope for such engineering talents as they possess ; that executive officers lead a more exciting life and have better prospects ; and that, above all, they command ships and enjoy responsibilities and privileges denied to engineer officers. Few of these reasons will, in fact, bear close analysis, and the Admiralty should have little difficulty in refuting them by a well-directed publicity campaign. As the Committee's report points out, an engineer officer's career in the Navy would be seen in a much more favourable light if its varied scope were better appreciated. Naval engineer officers may not command seagoing ships, but they command a number of shore establishments and, for long periods in their careers, starting as divisional officers, are placed in charge of large bodies of men. It is relevant to note in this connection that even an executive officer of captain's rank can expect to spend no more than two of his twelve or thirteen years' service in that rank in command of a ship at sea. Nor are the prospects of promotion of an engineer officer less favourable in general than those of executive officers. Indeed, up to the rank of captain—a relatively high rank in the Navy—they are even better. Above that rank prospects of advancement are unquestionably poor. We have repeatedly reproached the Admiralty that there are so few Rear-Admirals in so important a branch of the Service as the engineering one, and only one Vice-Admiral. However that deficiency is at least partially offset by the good prospects of engineer officers obtaining suitable employment on retirement between the ages of fifty and fifty-five. But when all is said and done, one of the more decisive factors, for the parent if not for the boy, is usually the financial inducement. A highly intelligent and ambitious lad with marked personality and initiative may well expect to reach Rear-Admiral's rank in the Engineering Branch at the age of fifty. This may not be so satisfying as to become a managing director or other high-ranking official in an industrial concern, but he will receive a basic income, if married, of £2666 per annum and, on retirement, a tax-free grant of £1000 and a pension—to which he will have contributed nothing—of £1200 a year. Similarly, the intelligent hard-working lad who does not aspire to these heights should have little difficulty in reaching the rank of a senior captain, with a basic salary of £1980 per annum, if married, and, on retirement, a pension of £1000 a year, with a tax-free grant also of £1000. If to these financial inducements are added a life at sea, visits to other countries, and a career which includes much of deep technical interest and the human duty of looking after the welfare and efficiency of large numbers of men, the Royal Navy can hardly be compared unfavourably with industry as a career for an engineer.

It is hoped, none the less, that the Admiralty will not be satisfied with existing arrangements. Under modern conditions the field of recruitment has been widened to take in those whose parents do not enjoy financial security. Thousands of boys have to leave school at sixteen every year for financial reasons and it is essential that any scheme of engineer officer recruitment should provide for boys of that age who are of the right standard. The War Office and Air Ministry have already schemes of this kind. The latter has a scheme of "preselecting" boys at sixteen years of age for subsequent entry into Cranwell and the offer of scholarships to enable them to stay on at their school. The War Office now has its own school at Welbeck College, which boys join at sixteen for the primary purpose of training for the technical branches of the Army. Surely it should be practicable for the Admiralty to institute a special class—the number of pupils would not in any event be large—at the Royal Naval Engineering College at Manadon for lads of sixteen when they leave school, or, alternatively, to adopt the Air Ministry scheme of "preselecting" cadets ?

CORNISH ENGINES

In our issue of August 28th last, we published an article by Mr. Tregoning Hooper, hon. secretary of the Cornish Engines Preservation Society extolling the achievements of Cornish engineers. In the same issue we referred editorially to the interesting ceremony to be performed during the following month when Lord Falmouth was to hand over to that Society (as indeed he did and as is recorded in our issue of September 18th) the 22in Rostowrack engine which had formerly been used for combined pumping and winding in one of his Lordship's china clay pits. That engine, upon the initiative of Mr. Treve Holman, has been re-erected in working order at the Camborne Engineering Museum. We also referred to the financial situation of the Society and foreshadowed that it would shortly be making an appeal for funds.

Of course, the Society, like any other, is hoping to increase its membership and thereby its annual income. But an assured annual

income, alone, is not sufficient to meet needs. Capital, also, is required. In the past the Society has benefited from the generosity of those who have given it property or who have made donations, large or small. But it cannot too much depend upon similar generosity in the future. For in acquiring the very modest number of extra properties that it plans to add to its collection and even more in putting those properties, whether they be engines, parts of engines, engine houses or other typical Cornish engineering products into "museum" order and making provision for their preservation, heavy expenses will have to be met. Those expenses can only be met out of capital. For, at best, income derived from members' subscriptions can hardly be expected to do more than meet the ordinary maintenance of properties once they have been put in order. The appeal the Society is now making, therefore, is for the formation of an endowment fund and the Institutions of Civil, Mechanical and Electrical Engineers, and the Institution of Mining and Metallurgy, have appointed Trustees for the fund. The natural people to whom to look for the really generous contributions to the fund that will be necessary if it is to be built up to an adequate size would be Cornish mining and engineering firms. But the great days of Cornish mining have long since passed. Firms that were responsible during the last century for building engines that surprised the world by their economy and for a period of forty or fifty years led the world in design, were compelled to cease work as the prosperity of Cornish mines faded. It is no longer possible—alas !—to request aid from such famous firms as Harvey and Co., of Hayle ; Sandys Vivian and Co., of Copperhouse, and the Perran Foundry Company. The Society is therefore asking firms elsewhere for help and appealing in particular to firms and organisations whose present work owes much to the pioneer work of Cornish engineers or lies within fields associated with the past work of Cornish engineers and miners. We hope that appeal will be successful and that it will arouse a really generous response. For, as any engineer who has visited Cornwall well knows, very few, out of the hundreds of engines once operating there, are still in existence and the only two still working, those at East Pool and South Crofty, are due to be superseded by electric machinery within a twelvemonth. The Society can only play its part in seeing that a few representative examples are preserved, together with a few amongst the hundreds of engine houses, most of which are now slowly decaying into ruins, providing it is sufficiently endowed to do so. We commend the appeal particularly to mechanical engineering firms. For Cornwall was one of the cradles of mechanical engineering. There, in succession, were used Newcomen, Watt and, later, " Cornish " engines. Thence, one amongst a constellation of famous men, came Trevithick, the originator of the Cornish boiler, of the high-pressure steam engine and of the locomotive. It would be tragic if, for want of a modest endowment, a few of the products of Cornish engineers were not preserved to show future generations what nature of men they were and how fine were their products.

Literature

High-temperature Alloys. CLAUDE L. CLARK. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 60s.

THIS book, as the author states in the Preface, deals with the subject of high-temperature alloys largely from an engineering viewpoint. The metallurgical aspect is, however, by no means ignored and the reasons why alloy additions are made, their effect on structure and mechanical properties are considered in some detail. The author is a metallurgical engineer with the Timken Roller Bearing Company, and although, as would be expected, the book has an American flavour, this does not detract from its value to those readers in this country, both engineers and metallurgists, whose work involves the selection and use of alloys for high-temperature service.

In the twenty-one chapters into which the book is divided the following subjects are dealt with :—Mechanism of plastic flow ; qualifications of alloys for high-temperature service ; methods of testing ; relative advantages of creep and stress rupture tests ; influence of alloying elements ; low alloy, intermediate alloy, straight chromium, austenitic and super alloys ; bolting steels ; representative service failures ; properties at hot processing temperatures ; selection of steels for specific applications.

The chapter dealing with service failures is very welcome, the effects of oxidation, corrosion, overheating and graphitisation being clearly described. In a chapter of physical constants the table giving values for Poisson's Ratio for a number of low and intermediate alloy steels at both room and elevated temperatures will be found invaluable. With regard to the relative merits of creep and stress rupture tests the author clearly indicates why more than one kind of test must be carried out to obtain adequate information concerning the behaviour of an alloy under stress and its ductility at fracture. Although perhaps too much emphasis has been placed on the stress rupture characteristics of alloys in the U.S.A., it is unfortunate that this test has largely been ignored in this country.

The author is to be congratulated on the use of both degrees Fahrenheit and degrees Centigrade throughout the text, and on the inclusion of the etching reagents used where photo-micrographs are reproduced. Other authors would do well to follow the same practice. For those wishing to study the subject further, references to other publications are given at the end of the book.

The book is a very useful addition to those already available on the subject and no reader can fail to benefit from a careful study of its contents.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

LOCOMOTIVE TESTING AT SWINDON

SIR,—Now that engineers engaged on locomotive development for use in Great Britain are almost exclusively under the thumb of state monopoly, many of us have ceased to regard the technical body catering for their interests as other than a mere platform for the display of British Railways' propaganda. It would therefore be more distressing to see the favourable bias of your editorial of November 27th, dealing with Mr. S. O. Ell's paper on Locomotive Testing, were it not for the number of double-edged barbs which react so deservedly against them.

" Around the scientifically determined performance characteristics of various types of locomotive the whole edifice of railway engineering and operating may now be built," so you say. Presumably this claim is based on the tests described in the paper between Coalpit Heath and Tilehurst, or the later remarks on runs between Paddington and Bristol. Is it coincidence that neither of these routes has a curve or a service slack (Bath only excepted) worthy of mention ? Or is this a matter of no importance, since, according to your view, speed-distance curves can now apparently be derived from loading and gradient alone ?

It would be interesting to speculate on the results of applying this new " exact science," say, to the former Midland route between Derby and Manchester Central, with its multiplicity of curves and speed restrictions and 1 in 90 ruling gradient over the 981ft summit at Peak Forest. The effects of working at constant evaporation, desirable as that may be in theory, would also be illuminating, for instance, if the rate going up one side were to equal that coming down the other. Similar interest is attached to the modifications which we may expect the civil engineers to make in the tracks when this new information on maximum possible speeds is placed at their disposal.

Is it coincidence, too, that your biased view ignores the statement : " The most efficient use of fuel therefore depends on the efficiency built into the locomotive, *and on the choice of the class of locomotive for the job . . .*" ? For does not Mr. Ell most commendably vindicate what many of us have said in the past, by thus disclosing the stupidity of the former Railway Executive in building only mixed traffic engines for universal duties ?

Finally, we gather that, with the reduction of steam locomotive evaluation to an exact science, the last obstacle to the perfectly planned railway system has apparently been removed. What excuses, other than sheer ineptitude, are still open to the poor Transport Commission for explaining away its failings in the future ?

" PYROTECHNIC "

Manchester, December 4th.

SIR,—May I question the suggestion in the first paragraph of your editorial article on locomotive testing that locomotive engineers do not know what they have been doing ? The " Kings " have been running for twenty-five years, and if it is a fact that Swindon has only just found out what they can do, that is hardly a cause for proclamation.

No locomotive engineer who has studied that matter need ever have been in much doubt about the " precise relations between the thermodynamic performance of the locomotive and the resulting motion of the train " ; the real uncertainties arise from the uncontrollably wide variations in day-to-day running conditions, and no amount of controlled testing can have any effect on them. What is the value of the ability " to relate basic coal consumption to the operation of the booked service " ? The actual consumption in service is what matters, and to determine it requires only an accurate means of weighing coal.

Quite frankly—and no doubt you would wish your readers to be frank—I found this leader very naïve. It expresses someone shyly seeking rich words of homage to something too deep for him to comprehend, whilst humbly bowed before it. This is not THE ENGINEER we used to know, but more like the sugary parts of the popular railway press.

M. DAVIES

Hoylake, Cheshire, November 30th.

SIR,—I have read your editorial on this subject and also Mr. Ell's paper, but I do not see why it should be claimed that accurate testing technique can be expected to improve day-to-day locomotive performance. Has not Swindon

technique on the test plant always been accurate ? On railways other than the Great Western have not good operating results been obtained with very little testing at all ?

So far as I have been able to distinguish, Swindon front end design is substantially that recommended by Goss in 1908. The " spectacular augmentation of maximum steaming capacity " of 89 per cent merely means that in its original form the locomotive concerned was not designed (as it could have been on the basis of existing knowledge) for so high an output as the boiler could produce.

You say that " time-table schedules can be prepared . . . (to) . . . correspond to the natural performance characteristics of the locomotive." In actual fact, Great Western time-tables, perhaps more than those of any other British railway, have presented extremely wide variations of power demand to the same class of locomotive on different duties.

To claim as a special virtue of accurate testing that it may answer with certainty the question " What is the highest speed at which a train is likely to pass a certain point ? " is a piece of special pleading that tends to discredit the value of testing at all. Is it really suggested that after 120 years of railway operation the civil engineers and the signal engineers of any one system do not know what train speeds are likely at any point on it ? Is it really insisted that only upon the publication of Mr. Ell's paper in the year 1953 we are able to say that " the whole edifice of railway engineering and operating may now be built ? "

W. A. TUPLIN
Professor of Applied Mechanics
University of Sheffield
Sheffield, November 27th.

TECHNICAL DISCUSSIONS OF ROCKET PROBLEMS

SIR,—The twelve societies comprising the International Astronautical Federation contains between them over 6000 members, including a very substantial proportion of the leaders in the field of rocket propulsion. Though most of these men will also be members of the older scientific and engineering societies, I believe the majority would strongly object to your suggestion that any existing body take over the activities already carried out by the American Rocket Society, the Gesellschaft für Weltraumfahrt and the British Interplanetary Society—to mention only the three largest members of the I.A.F. In particular, the proposal that the Institution of Mechanical Engineers be responsible for fostering extra-atmospheric applications of the rocket will not bear serious examination.

While it is agreed that it is undesirable for a large number of " splinter groups " to be formed, each dealing only with very specialised technical interests, nevertheless, it is desirable that a new group be founded whenever some large new subject arises. This is particularly true when that new subject embraces many diverse older branches of knowledge, and when it introduces new concepts and proposals which the orthodox world of science and technology initially views with some scepticism, indifference, or even opposition (as is too often the case). Thus, when aeronautics reached a stage where it deserved to be taken seriously, its further progress was greatly aided by the formation of the Royal Aeronautical Society—not by any action of the Institution of Mechanical Engineers. Even had that body been prepared to take an early interest in aviation, it is most unlikely that any such small section of enthusiasts within it would have exerted much influence on the course of events. Most likely they would have been regarded, tolerantly or otherwise, as mere eccentrics.

If there was a case now for using any of the existing engineering societies as the main medium for discussion of space flight, the Royal Aeronautical Society would perhaps be a better choice. When one considers what is implied in astronautical development, however, it becomes immediately obvious that none of the older organisations (even including the R.Ae.S.) could deal adequately with all phases of the subject. Its mechanical aspects—the design of rocket motors, structural considerations, &c.—form only a part of the whole problem. Equally important are such subjects as electronics, celestial mechanics, medicine, applied physics (including nucleonics) and chemistry. A great many (probably even a majority) of the specialists now involved in rocket activities have no interest in mechanical engineering as such, and are more likely to be members of the R.Ae.S., the R.A.S., the I.E.E., or the Institutes of Physics and Chemistry, than of the I.Mech.E.

The British Interplanetary Society already carries out the duty you suggest of providing facilities for rocket engineers to meet and discuss their problems. Holding about forty meetings a year at its various branches, it has presented and published in its *Journal* many papers on rocket development, and would do far more of this sort of thing were it not for unavoidable considerations of security. The current (November) *Journal* is an excellent example : it contains important papers by W. N. Neat, B.A., A.F.R.Ae.S., on " Some Limiting Factors of Chemical Rockets," and by K. W. Gatland, A. M. Kunesch and A. E. Dixon on " The Fabrication of the Orbital Vehicle." On December 12th, H. Ziebland, A.M.I.Mech.E., presents a paper on " A Review of the Current Techniques of Protecting and Cooling Rocket Motor Walls." Such lectures are, of course, open to members of all other technical societies. The B.I.S. has also devoted a great deal of effort to getting technical information declassified, with a little success in this notoriously difficult enterprise.

It would seem, therefore, that the objects you have in mind are already quite well provided for, and would not be furthered by the suggestions you make.

ARTHUR C. CLARKE
Chairman, British Interplanetary Society.
November 24th.

[There is a misunderstanding. Our point is that the British Interplanetary Society is a body primarily concerned to promote space-flight. Similarly, the Royal Aeronautical Society is primarily concerned to further the progress of aeronautics. There seems to us to be room, additionally, for the discussion of the technical problems of rockets in the more purely engineering sense by some body not concerned to press development in any special direction. That body should clearly be one of the three major engineering institutions, and the Institution of Mechanical Engineers seems the most appropriate. It would not be doing its job if it tried especially to make itself " responsible for fostering extra-atmospheric applications of the rocket." ED. THE E.]

TIDAL SLUICE GATES

SIR,—In THE ENGINEER for February 13, 1953, you published an article which included a description and illustration of the side-hung sluice gates built in the time of Gelfred de Gatesby, Abbot of Selby, 1341–1362. The Keeper of the Yorkshire Museum has made further researches from which it is clear evidence exists that the Riccall gates replaced sluices and a mill of a much earlier date. The evidence consists of a document " Commission to William Basset, William de Redenesse, Knight, Robert de Haldanby and John de Beckingham. Westminster, 10 July, 17 Edward III (1343). Inquisition before the said Robert and John. Rikhale, Friday the feast of the beheading of St. John the Baptist."

The commission was to inquire into flooding due to the lack of repair to the banks and sewers. The summary of evidence includes :

" The prebendary of Rikhale had a mill on the sewer at a place called Rikhaldam and a stank raised to a certain height, whereon was a causeway for carts and wagons and underneath sluices 6 feet wide to let off the water.

" The prebendaries had the mill from time beyond memory and maintained the stank until Bartholomew Florenty, prebendary in the time of King Edward I, thinking that it would be more to his profit to destroy the mill than to maintain it, destroyed the mill and stank, so that the waters of Use at every time of increase has overflowed the said lands and others.

" It would be best for the men of the said towns to have the banks heightened and sluices of a certain width on the Use at the mouth of the sewer."

Calendar of Inquisition, Miscellaneous II, 1307–1349, No. 1828, pages 454–455.

We have therefore clear contemporary evidence that there were sluices at Riccall dam, which were old and out of repair not only by 1343, but had been allowed to get out of repair forty years earlier in the time of Edward I.

From the position of the mill at " Rikhaldam," it was in all probability a tide mill—that is to say, the tide filled the mill pond, and was released by a sluice to operate the mill wheel. It would be interesting to know if any of these early mills, making use of the tides for power, are still in use in this country. There is one at Woodbridge, Suffolk, which dates from 1495 or much earlier, but it is not now working.

E. C. BOWDEN-SMITH, M.I.Mech.E.
Westminster, S.W.1, December 2nd.

PERFORMANCE OF CARS

SIR,—After reading the many recent articles on the exhibits at the Motor Show, it has occurred to me that comparison between cars would be much simplified if figures for overall efficiency were available. These might be based on the calorific value of fuel consumed in providing given outputs to the road wheels, and if these outputs represented the conditions, easy driving, as in 30 m.p.h. areas, hard fast driving, as on long journeys, together with a test in each lower gear, more reproducible figures for comparison would be available than from the present " road test " results. In order to cater for the effect of the differential it might be necessary to lock one wheel and take off the whole output from the other.

As the general public has become quite used to reading of efficiencies of 15 to 25 per cent in connection with the utilisation of coal in the home and in power stations, &c., the comparably low figures likely to be obtained on cars would not come as an undue shock.

W. H. DEVENISH, A.M.I.E.E.
Ewell, Surrey, December 1st.

Statement on Road Expenditure

IN the House of Commons, on Tuesday last, Mr. Lennox Boyd, Minister of Transport and Civil Aviation, made a statement about the Government's plans for road expenditure during the next few years. He said that the severe economies in capital investment which the Government and its predecessors had been compelled to impose, coming on top of wartime restrictions, had meant that for the past fourteen years or so the highway system of this country had been largely starved of development. There had at the same time been a substantial increase in traffic, particularly heavy traffic. The Government had decided, Mr. Lennox Boyd continued, that there should be a considerable increase of expenditure on road improvements and it contemplated increased annual payments from the Road Fund for that purpose rising from the present level of about £5,000,000 per year to between £14,000,000 and £15,000,000 in 1957–58, continuing at that level for some years. It was intended to approve in the next financial year,

he said, schemes representing a total Government expenditure over the whole period of their execution of more than £19,000,000, and the total Exchequer expenditure on schemes to be authorised in the next three years would be about £50,000,000.

Of the schemes to be approved in 1953–54, Mr. Lennox Boyd pointed out that £4,500,000 of the total Exchequer expenditure of over £19,000,000 would fall to Scotland, including £3,000,000 for the Whiteinch-Linthouse tunnel in Glasgow. In Wales, he continued, the Government hoped to include a scheme for the reconstruction of Conway Bridge in next year's programme. In England, the schemes to be authorised during the next financial year, he noted, included the following :—Cromwell Road extension ; the Wilderspool level crossing, Warrington (A.45)—provision of a bridge ; East Retford by-pass (Great North Road)—first part ; Doncaster Mill bridge—reconstruction and widening ; Cavendish Bridge (A.6)—replacement of temporary bridge ; Markyate by-pass (A.5) ; Stafford-Stoke Road (A.34)—provision of three lengths of dual carriageway ; Western Avenue (Middlesex) (A.40)—duplication of carriageways ; Loughton (Bucks) by-pass (A.5) ; and Ashford (Kent) by-pass—completion.

There would, of course, be a substantial number of smaller schemes, Mr. Lennox Boyd went on, amounting in the first three years to several million pounds, and in selecting them he had paid particular regard to "black spots," where a comparatively small expenditure was likely to bring a big dividend in road safety. He also gave a list of further large schemes which it was hoped to authorise during the next three years. Mr. Lennox Boyd regretted that the Government's resources were not sufficient to include such major and desirable projects as the Forth and Severn bridges in the present programme.

Books Received

Versuche an Zylinder-Schneckentrieben. By Eduard Heyer. Germany : Friedr. Vieweg and Sohn, Braunschweig. Price Dmk.18·80.

Basic Mechanics of Fluids. By Hunter Rouse and J. W. Howe. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 36s.

Petroleum and Performance. By E. M. Goodger. London : Butterworth's Scientific Publications, Ltd., 88, Kingsway, W.C.2. Price 32s. 6d.

Chemical Process Machinery. Second edition. By E. R. Riegel. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 100s.

Introduction To Valves. By R. W. Hallows. London : Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 8s. 6d.

Applied Thermodynamics. Second edition. By A. C. Walshaw. Glasgow : Blackie and Son, Ltd., 17, Stanhope Street, C.4. Price 40s.

Marine Steam Boilers. By J. H. Milton. London : George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 27s. 6d.

Above Us The Waves. By C. E. T. Warren and J. Benson. London : George G. Harrap and Co., Ltd., 182, High Holborn, W.C.1. Price 15s.

Whillans's Tax Tables and Tax Reckoner, 1953–54. By George Whillans. London : Butterworth and Co. (Publishers), Ltd. Price one to five copies 5s.

Watch and Clock Making and Repairing. By W. J. Gazeley. London : George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 42s.

D.C. Generators and Motors. By J. E. Macfarlane. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 8s. 6d.

Berechnung von Einfachen und Mehrfachen Rautenträgern. By Maria Eblinger. Germany : Springer-Verlag, Berlin, W.35, Reichpietschufer. Price Dmk.15.

Practical Design of Simple Steel Structures. Volume II. Third edition. By Dr. D. S. Stewart. London : Constable and Co., Ltd., 10, Orange Street, W.C.2. Price 25s.

Handbuch der Hartmetallwerkzeuge. By W. Dawihl and E. Dinglinger. Germany : Springer-Verlag, Berlin W.35, Reichpietschufer 20. Price Dmk.15·60.

Statistics for Technologists. By G. G. Paradine and B. H. P. Rivett. London : The English Universities Press, Ltd., Saint Paul's House, Warwick Square, E.C.4. Price 25s.

Iron and Steel Institute

AUTUMN GENERAL MEETING

No. II—(*Continued from page 737, December 4th*)

THE afternoon session of the Iron and Steel Institute's autumn meeting on Tuesday, November 24th, concluded with a discussion on the following paper :—

THE WATER COOLING OF OPEN-HEARTH FURNACES

By A. M. Frankau, M.A.

Synopsis

A series of measurements has been made on a number of open-hearth furnaces of the flow rate and temperature rise of the cooling water supplied to the individual cooling units. The heat losses imposed by these units are an important factor in furnace operation, as it has been shown from these trials that they can involve a high proportion of the heat input. It is calculated that the required heat input for a given heat loss is in the ratio of 1·8 : 1 for oil firing and 2·1 : 1 for producer gas firing.

Trials on a tilting furnace during a single campaign showed that the measured heat loss rose from 11·4 to 15·7 per cent of the total heat input. This increase was due to severe erosion of the refractory covering the cooling units in the port ends.

The largest heat losses occurred in units such as furnace chills and door frames, where there were surfaces unprotected by refractory and subject to direct radiation or gas impingement. It is therefore recommended that every effort should be made to ensure adequate covering of the cooling units wherever possible.

Discussion

Mr. Y. A. Calderwood (Wellman Smith Owen Engineering) : When we were asked to open the discussion on this paper, I looked up what records we have on the subject and the point that stood out most clearly among them was the complete lack of uniformity or standardisation. Mr. Frankau, in his excellent paper, gives figures which tend to confirm this observation. He mentions a figure of 36 tons of water circulated per ton of steel made, which is extremely high, and he gives a case where the temperature rise of the cooling water is given as only 3·9 deg. Fah., which again seems out of proportion.

One asks, of course, why this variation. There are several reasons indicated in the paper, but the most important is given in one short sentence. It says: "The quantity of water needed for circulation depends more on the quality of the water used than on the temperature rise between inlet and outlet." Herein lies the crux of the matter, and, as furnace designers and builders, a matter on which we can speak with some feeling, because there are occasions when the local source of water supply is such as virtually to dictate how the water cooling shall be effected, in a way not always to our liking.

This loss of heat by cooling water can be a serious matter. J. S. Curphy, in his paper in the August edition of the *I.S.I. Journal*, quotes a figure of 2s. per ingot ton for a heat loss of 10 per cent of the total heat input, which might well be regarded in the region of a minimum figure. Mr. Frankau quotes maximum losses equivalent to 1400 gallons of fuel oil or 10 tons of gas producer coal per day, worth about £53 and £32 respectively on present-day prices. And these appear to be net figures, since Mr. Frankau significantly states : "any measured heat losses can be increased by at least a half to give the heat input required."

Now, we were asked by B.I.S.R.A. to give our views on what we consider the proper application of water cooling—not a simple matter by any means. Perhaps the true answer to this request is to ask how seriously the steel industry is going to tackle the problem. Our general experience is that on an open-hearth plant the water inlet valve is turned full on right from the start, and there it stays.

To tackle the problem properly will cost money, e.g. measuring instruments and possibly automatic control will be required, or special hand control valves ; or we can take a leaf out of the German book with the use of low or high-pressure steam instead. It is for the industry to decide whether or not a change is necessary.

Dr. A. H. Leckie (B.I.S.R.A.) : That heat losses of this kind were accepted apparently with equanimity by various steel makers showed that the seriousness of the problem could not have been properly realised. The magnitude of some of the losses is really staggering.

One of the biggest sources of loss of heat that one sees is the door frames. I have always heard it said (it may be wrong) that the chief reason for water cooling a door frame is that charge drivers will knock down the brickwork of an ordinary brick door without this kind of protection. If so, I wonder whether Mr. Frankau has gone into the question of the relative merits of small and large doors, because presumably one should have the door as big as possible in order to get a lot of material in quickly with the minimum damage to the frames. On the other hand, that will mean a greater heat loss both through air infiltration and through water cooling ; but it would seem that the use of larger doors is the first thing which will ease this particular problem. I wonder whether Mr. Frankau has considered all these aspects with a view to minimising water cooling losses as well as just measuring what they are.

I feel that this paper very impressively draws attention to this serious matter. It is really shocking to find 27 per cent of heat losses on water cooling in one case. I remember visiting a furnace which was not working well and where some 30 per cent of the heat was going in this way.

Mr. C. R. Banks (Blaw Knox, Ltd.) : Why is water cooling used so extensively in steel plants throughout this country and the rest of the world ? The answer is pretty obvious. The advantages have been listed by Mr. Frankau. To summarise, it keeps a furnace in good shape for a longer period of time, it helps to maintain tightness around the doors, and it does a deal to eliminate hot repairs. All these factors, added together, make for an efficiency which does not unduly diminish through the campaign of a furnace, and that is a most desirable condition, and as such it is related to fuel consumption which, in the case of a producer gas furnace, depends on maintaining consistently a good shape of flame throughout the campaign, which can only be achieved with water cooling around the ports, and depends also on keeping the number of hot repairs down to a minimum.

Those factors have to be thrown into the balance against the losses to decide whether water cooling as we know it is worth while. There is no doubt that this must have been done by most of the plants using water cooling, and it must have been justified.

Mr. M. P. Newby (B.I.S.R.A.) : The emphasis this afternoon has rightly been mainly on the heat loss in water cooling systems, but there is another aspect of the problem, and that is the quantity of water used in the system. The heat loss will depend mainly on the overall furnace design, but the

quantity of water used will depend mainly on the internal design of the water cooling system. If there is an absolute dead zone of no circulation in a water cooling system, obviously that is going to be exceedingly inefficient, and it must be eliminated completely. One also wants to eliminate zones of low water velocity, because there the water cooling will be poor, and if the water velocity is high enough in the worst points then it will be far too high at the good points.

Mr. J. H. Flux (United Steel Companies, Ltd.) : What we would like to have is something in the nature of a balance sheet to establish the relative advantages of water cooling and having uncooled parts, with furnace design as it is to-day. I was hoping to get that in Mr. Frankau's paper, but I did not get it.

In the course of the discussion there has been mention of the use of steam cooling. We have looked into that matter. Steam cooling does not reduce the heat loss, but it certainly takes advantage of it. So far as I can see, with an 80-ton or a 100-ton furnace, with steam cooling you would generate steam to the extent of about one-third of what you would get from a waste heat boiler on that furnace, but the capital cost of the steam cooling equipment would be per pound of steel roughly that of a waste heat boiler. The question is whether it is worth while putting in all the additional pipework and conglomeration of equipment which is necessary.

At the morning session on Wednesday, November 25th, a joint discussion was held on the following papers.

THE NOTCHED SLOW-BEND TEST AS A BRITTLE FRACTURE TEST.

By J. E. DE GRAAF and J. H. VAN DER VEEN.

Synopsis

The paper gives additional information on the notched slow-bend test, described in a previous paper. The experiments that led to the choice of a 3mm deep pressed notch in the standard test, and, in addition, experience with deeper notches, especially in regard to the conditions affecting the arrest of crystalline fracture, are discussed. The phenomena at the root of the notch up to the start of incipient fracture, and those related to the strain distribution in bending are also discussed. Experimental evidence showing that no unequivocal correlation exists between several of the criteria for brittle fracture is given. This suggests that a test in which the different criteria can be determined separately is preferable. In a statistical analysis of test data, Charpy V-notch and notched slow-bend tests are compared, and it is shown that, in quality inspection of plates, the uncertainty of the notched-bend test is less than that of the Charpy V-test by a factor of more than 2.

THE FRACTURE OF ALPHA IRON.

By C. F. TIPPER and E. O. HALL.

Synopsis

The paper describes tests made on silicon ferrite and carbonyl iron in the form of single crystals and in the polycrystalline state. The formation of Neumann lamellæ and cleavage planes were studied and the stress to fracture was measured. The stress normal to the fracture plane in four crystals of iron was not constant.

INTERGRANULAR BRITTLENESS IN IRON-OXYGEN ALLOYS.

By W. P. REES and B. E. HOPKINS.

Synopsis

The tensile and impact properties of high-purity iron and iron-oxygen alloys, at various temperatures covering the tough to brittle transition, are discussed. The addition of more than 0·003 per cent of oxygen produced marked intergranular embrittlement, accompanied by a sharp rise in impact transmission temperature. Oxygen had little effect on the resistance to plastic deformation, but it had a large effect in reducing the brittle fracture strength. The addition of manganese largely counteracted the influence of oxygen.

THE CLEAVAGE STRENGTH OF POLY-CRYSTALS.

By N. J. PETCH.

Synopsis

Using mild steel, ingot iron and spectrographic iron, it is found that the cleavage strength σ_c is related to the grain size l by

$$\sigma_c = \sigma_0 + kl^{-\frac{1}{2}}.$$

This can be explained if the Griffith cracks can be identified with glide planes on which dislocation movement has been blocked by the grain boundaries.

According to this theory, the cleavage strength of the polycrystals is controlled by the theoretical cleavage strength in the grain boundary region, which opens up the possibility of subtle composition effects in this special region, by the grain size, which determines the stress concentration factor, and by σ_0. The plastic strain at fracture is greater when the grains are finer and the strain hardening rate is lower.

Discussion

Mr. A. J. K. Honeyman (Steel Company of Wales) : We have before us two kinds of papers : the first, by Professor de Graaf and Dr. van der Veen, dealing with the practical aspect, and the remaining three papers dealing with the theoretical aspects.

Professor de Graaf and Dr. van der Veen discuss the problem of test conditions. When the problem of brittle fracture first came into being there was an urgent demand for producing better steels, and it was then empirically and quickly found that manganese was the practical answer to the problem, but we did not know why manganese was so effective and also we did not know exactly what we were testing when we were doing an impact test—and that is the subject dealt with by Professor de Graaf and Dr. van der Veen in their paper.

Two of the remaining papers deal with the more fundamental aspects of the problem of brittle fracture. Dr. Tipper has written many papers—possibly more than anyone else—on brittle fracture ; but on this occasion she has, in collaboration with Dr. Hall, broken new ground by going for fundamentals.

With regard to the paper by Mr. Rees and Mr. Hopkins, perhaps the two most interesting and puzzling points in the paper are, first, the fact that they have not been able to find any intergranular phase to account for the progressive increase in the intercrystalline failure and in weakness ; and secondly, the fact that all the other specimens were coarse-grained. Unfortunately, every author seems to have his own method of describing grain size, and one has a bit of a headache in working out the arithmetic of it. I should like to ask if it is possible to obtain those oxygen alloys with a fine grain. Dr. Petch had no difficulty in his case by using various rates of cooling. Would it be possible, with a faster rate of cooling, to obtain those oxygen-alloyed steels in fine-grain form, and, if so, would this intercrystalline brittleness still exist ?

I am particularly interested in Dr. Petch's paper, and I think I may say that it is a classic. There can be nothing more gratifying to a physicist than to find his theoretical reasoning and calculations confirmed by practical results, or vice versa. The equation describing relationship between grain size and cleavage strength takes no account of precipitation, and Dr. Petch warns us that it does not apply when such effects are present ; but it is difficult to see how some, at least, of the grain sizes produced were not accompanied by precipitation effects.

Dr. N. P. Allen (National Physical Laboratory) : In regard to the paper by Professor de Graaf and Dr. van der Veen, the authors make the point that their notch-bend test has less scatter in it than the V-notch impact test. I think they establish their point, but I wonder whether the real reason for that is that their notch-bend test is done on a very much larger specimen and therefore they take a better sample of the steel as a whole in the one test.

I am glad to hear that the authors are using their test to examine the variations between different heats of steel and different methods of making steel. It is found that the ordinary mild steel varies unexpectedly wildly from heat to heat, and it is necessary to find out now how various procedures in manufacture affect the susceptibility and how it can be controlled, so that the average quality of mild steel shall be equal to the best which is now accidentally produced.

At the National Physical Laboratory we have done quite a lot of work on single crystals. I should like to say only that I agree with Dr. Tipper and Dr. Hall entirely that there seems to be no very necessary connection between the production of Neumann lamellæ and the appearance of fracture.

Dr. Petch wants to persuade us that the dominant factor in the brittle fracture is the grain size ; but I should like to point out also that his specimens contain not enough carbon to saturate the ferrite, and consequently precipitations of carbon may be going on throughout all the experiments, and it is necessary to know better the effect of carbon going in and out of solution and the carbide form and the effect of grain size. I think there is going to be a lot of argument before that matter is settled.

Dr. Petch has pointed out that the theory leads to the idea that the cleavage stress shall be linear with the square root of the grain diameter, and I think it should be pointed out that that is not what has happened. What has happened is that we have had to introduce an arbitrary assumption to account for the difference. The reason suggested in the paper is not a very good one, and I think that Dr. Petch has already (judging from his remarks in presenting the paper) gone away from it. The idea that it is the atmosphere of dislocations round the slip plane and its effect that produces this difference cannot be very true, because that atmosphere of dislocations must consist of equal numbers of positive and negative, and their effects will cancel out and produce nothing. I think that the second idea that it is the frictional resistance to the passage of dislocations which causes the difference is a much more promising one to follow up.

This work on single crystals has given us an opportunity of criticising the general notions to some extent. The idea we have is that the dislocations travel along and get held up at the boundary ; they produce a high stress which causes the material to break at the next crystal. But with a single crystal there is no next crystal, and therefore a single crystal ought not to undergo a brittle fracture. Now, single crystals do undergo brittle fractures, and if we consider a single crystal we can imagine that two things might happen. First, the dislocations pass out at the surface and produce no stress, in which case the single crystal should be ductile ; or else there may be some zones in the single crystal and the dislocations may pass along the crystal and get held up somewhere and produce the same crystals as they would in the polycrystalline mass and cause the cleavage to begin. In those circumstances single crystals would be expected to be most brittle of all materials. But what the theory does not prepare us to find is that the single crystal actually is sometimes brittle and sometimes ductile ; that is what the behaviour actually is, and it is rather difficult to see just how that fact is to be accommodated in such a theory as this.

Mr. J. E. McLennan (National Physical Laboratory) : Similar work to that described by Dr. Tipper and Dr. Hall has been proceeding at the N.P.L. during the past two years. We have tested in tension over fifty crystals at temperatures ranging from 100 deg. Cent. to −253 deg. Cent. The iron contained 0·003 per cent carbon with similar amounts of other impurities.

In many ways our results confirm those reported in this paper. At the higher temperatures crystals of any orientation deform by slip to give 100 per cent reduction in area. At low temperatures crystals of certain orientations cleave without prior deformation, others twin, and still others of different orientation deform by slip. At lower temperatures still all crystals become brittle. At temperatures down to −196 deg. Cent. the choice of slip system seems to depend both on orientation and on temperature. At −196 deg. Cent. cleavage on (100) plane occurs without prior slip when this direction of stress is within 20 deg. to 30 deg. of the (100) direction. Otherwise the crystals behave in a ductile manner. At certain orientations twinning precedes cleavage, and at others twinning precedes slip. Elsewhere slip alone occurs. Crystals other than those deformed by slip did not give 100 per cent reduction in area. The results suggest that the critical resolved stress for twinning is about two-thirds the critical resolved stress for slip.

At −253 deg. Cent. all the crystals broke by cleavage, although in some instances twins were formed first. The resolved fracture stress normal to the cleavage plane was about 60,000 p.s.i. at −196 deg. Cent., and about 80,000 p.s.i. at −253 deg. Cent. These few results suggest that the cleavage strength is strongly dependent on temperature and is not more or less constant. The critical shear stresses for slip and twinning both rise rapidly with fall in temperature, that for slip the more rapidly of the two.

Examination of the fractures suggested that twins which were not formed prior to cleavage could be obtained in two ways : (1) by formation ahead of the propagating crack, since Neumann lamellæ matched in both halves of the fracture face ; and (2) by shock waves as a result of fracture. The twins found well away from the fracture were most likely formed in this way. Twin traces on the surface of the crystals could be followed across the cleavage face, so there was no doubt that the marks on the fracture were twins.

Dr. A. Wells (B.W.R.A.) : With regard to the paper by Dr. Tipper and Dr. Hall, I was rather sorry to see that the experiments did not show any confirmation of Sohncke's law. We have been disappointed a little over the characteristics of shear, which do not seem to obey any simple law. We had hoped the cleavage would. It has been confirmed by a number of people that the cleavage plane is one definite plane, and we might have thought that the sine-square law would operate. I wonder whether the authors could state a little more clearly in their reply whether they still hope for this.

Dr. P. L. Pratt (Birmingham University) : Dr. Petch suggests that " actual cracks of the Griffith form in a metal would close up in the absence of external stress unless they were prevented from doing so by included atoms," and that is a very reasonable statement ; but surely the external stress is there when one is pulling a single or a polycrystalline specimen and it is on the verge of cracking. If one, in fact, believes that the cracks may be developing during the deformation before fracture, the thing that one should do to Dr. Petch's calculations is to compare the grain size, which in his case is the effective crack length, with the sort of crack length that one can calculate after the manner shown by Orowan, where you introduce the plastic strain factor into the Griffith criterion.

Mr. G. Murray Boyd (Lloyd's Register of Shipping) : The problem of notch brittleness in mild steel, or rather the problem of its control from the practical engineer's point of view, has given rise to the invention of many different kinds of tests, all intended to discriminate between suitable and unsuitable steels from this viewpoint. The multiplicity of such tests has set a serious problem for those in whose interest it is to select the one which is best. This selection is in itself a problem comparable in magnitude and difficulty with that of elucidating the phenomenon itself.

From the user's point of view any such test must stand or fall on its ability to comply with three main conditions, i.e. (1) it must correlate with service performance ; (2) its indications must be as free as possible from personal errors of judgment ; and (3) it must be practical and economical to apply.

From the paper it is evident that conditions (2) and (3) are fairly well met by the proposed test, but little evidence is given on condition (1).

The meeting then discussed the paper " Tensile and Impact Properties of High-Purity Iron-Carbon and Iron-Carbon-Manganese Alloys of Low Carbon Content," by N. P. Allen, D.Sc., M.Met., F.I.M., W. P. Rees, M.Sc., F.I.M., B. E. Hopkins, M.Sc., and H. R. Tipler, B.Met.

Dr. A. Wells (B.W.R.A.) : It seems to me that since the investigators are getting so far in this study of both shear and cleavage in ferrous materials, very firm attention ought to be given to improving the Charpy test as a measure. It is high time that we really could measure the cleavage strength of materials at temperatures other than those of liquid air. I suppose that one possible way in which it might be done would be with spherical samples in which all trace of shear at the centre could be eliminated, and one might induce the stresses by some such treatment as a sudden immersion in a different-temperature bath. This might not be the only way to do it.

(To be continued)

High-Pressure Turbo-Supercharger

(By Our American Correspondent)

A NEW range of turbo-superchargers designed specifically for high-pressure supercharging service is being developed by the De Laval Steam Turbine Company, of Trenton, New Jersey. An initial unit was designed for a pressure ratio of 2 : 1 under full-load engine operating conditions, and a slightly higher ratio under engine overload conditions. Later models are being planned to be capable of producing pressure ratios of 3 : 1 under engine full-load conditions. The compressor is of the mixed-flow type, in which the air enters axially and flows through and out of the impellers partly axially and partly radially. This kind of compressor, it is claimed, gives efficiencies and performance characteristics which are substantially better than those which can be achieved with either the axial-flow or the radial-flow centrifugal compressor. A departure from conventional practice was also made in the design of the turbine, because it was found that the desired turbine characteristics and high turbine efficiency could not be obtained by using the conventional axial-flow design of turbine. The mixed-flow centripetal turbine was found to be much more suitable for service in exhaust gas turbine-driven superchargers. A useful property of the centripetal turbine is the fact that its blades are rugged and they are few in number.

An interesting aspect of the De Laval turbo-supercharger is the construction of its rotor. The mixed-flow impeller and the centripetal turbine wheel are combined in a single rotor structure in which the compressor blading is carried on one side of the rotor hub and the turbine blading on the opposite side. This arrangement is said to eliminate all parasitic losses such as turbine and compressor leakage, windage and friction of non-working surfaces. By eliminating these losses the turbine and compressor efficiencies were substantially improved, over and above the improvements already achieved by the aerodynamically improved mixed-flow compressor blading and the centripetal turbine blade configuration. This so-called " Monorotor " construction offers the additional advantage of simplicity, eliminating a great number of parts, such as air and gas seals and partition walls. The blades of both the compressor and the turbine are open along their entire tip contour, and their configuration discourages the accumulation of dirt, with its resulting loss of performance. The overhung rotor is bolted to the end of the shaft by means of a single central tie bolt. The shaft is supported in two bearings, which are situated on the cold side of the rotor and contained in a common bearing housing that is an integral coaxial part of the compressor inlet casing. The mixed-flow compressor has an axial air inlet and a vaneless diffuser, terminating in a scroll housing, from which the air is discharged tangentially. The use of a vaneless diffuser is largely responsible for the wide compressor operating range, and makes the compressor capable of serving a variety of engines having different air flow requirements.

The turbine nozzle box receives the engine exhaust gases in a tangential direction, through a single inlet, and contains the turbine nozzle guide vanes which provide for full admission in all applications. These guide vanes are arranged between two radial walls and are so mounted that they can readily be pivoted to change the nozzle area. This arrangement eliminates the need for installing different nozzle rings to adapt the unit to different operating conditions, and permits the rapid matching of engine and turbo-supercharger. In some units a mechanism has been incorporated which permits adjusting the guide vane position from the outside during operation of the turbo-charger. This externally adjustable guide vane mechanism has been found invaluable when used as a tool to perform rapidly a series of tests leading to the best matching of turbo-supercharger and engine. It can also be used for varying the turbo-supercharger speed with changing engine load or speed, to achieve various engine operating characteristics, such as high torque at low engine speed. The guide vanes direct the flow of exhaust gases radially inward into the turbine blades, whence they are discharged into the passages formed by the blades of the turbine wheel. The exhaust gases are then discharged into an exhaust diffuser, which is coaxial with and a part of the turbine housing. This diffuser serves to recover some of the kinetic energy represented by the leaving velocity at the discharge from the turbine blades and to convey the gases to the turbine discharge opening.

The turbine housing is made from a heat-resisting alloy and is insulated and lagged instead of being water cooled. The turbine nozzle box is separated from the compressor housing by a central partition diaphragm, which is hollow to facilitate internal water circulation. It is the only water-cooled part of the entire unit. Tests made by the firm indicate that the amount of heat rejected to the small quantity of cooling water required is insignificant compared with the heat carried away in the cooling water for the commonly used turbine casing cooling jackets. The " Monorotor " construction of the turbine wheel and the compressor impeller permits cooling of the turbine side of the rotor in a simple manner, by by-passing approximately 5 per cent of the air handled by the compressor over the periphery of the rotor to the turbine. The air so by-passed flows in the form of a thin film over the turbine rotor hub, blanketing it from the heat of the gases. This cooling effect is augmented by the provision of cooling air flow through the hollow interior of the rotor and through cooling passages directly adjacent to the turbine blade roots. The De Laval turbine operates with full admission and steady flow at all times and it has an undivided nozzle box. To recover the pulsating portion of the exhaust energy the several branches of the exhaust manifold are connected to the single turbine inlet by means of an adaptor piece called the " pulse converter adaptor." This device is designed to convert the pulsating portion of the exhaust energy into a pressure rise, so that the pre-turbine pressure will be higher than the mean pressure in the exhaust manifold.

AGRICULTURAL MACHINERY AT THE SMITHFIELD SHOW

Fig. 7—Mounted Fertiliser Distributor—Transplanters (Robot)

Fig. 8—Fiat "55L" Industrial Tractor—Mackay

Fig. 9—Lanz Tool Carrier—Leverton

Fig. 10—Automatic Pick-up Baler—Bamfords

Smithfield Show and Agricultural Machinery Exhibition

No. II—(*Concluded from page 732, December 4th*)

THE Smithfield Show and Agricultural Machinery Exhibition opened at Earls Court, London, last Monday morning, and throughout the week has been attracting a large number of visitors from all parts of this country and from many countries overseas. The show will end this (Friday) evening. The exhibits of cattle, sheep and pigs, though a little less numerically than last year, are undoubtedly up to the high standard associated with the Smithfield. On the other hand, the amount of space devoted to the exhibition of machinery and implements is a little greater than last year and must, in fact, now be taxed to capacity. It has been said more than once during the week that the "Smithfield" is now one-fifth cattle and four-fifths machinery and equipment. The engineering interest of the show thus increases. The array of machinery and implements to be seen at Earls Court this week emphasises once again the progress of mechanised agriculture in this country and also abroad, for the agricultural machinery industry's contribution to Britain's export trade is one of increasing importance.

We conclude below our description of a selection of the machinery exhibits.

Transplanters (Robot), Ltd.

A tractor-mounted fertiliser distributor with a sowing width of 24ft is exhibited by Transplanters (Robot), Ltd., Sandridge, St. Albans, Herts. It can deal with all granular and the majority of powdered fertilisers, the total capacity of the two hoppers being 10 cwt of granular material or up to 12 cwt of powder. The distributor is driven from the power take-off shaft of the tractor and is mounted on the rear link arms. The distributing mechanism consists of two reinforced moulded rubber conveyor belts, which have been rendered resistant to acid and moisture, each of which is driven by two pulleys rotating at the bottom of the hoppers. The fertiliser escapes, as it is carried along the belts, through a series of progressively inclined slots cut in the aluminium plate sections. A four-speed gearbox is incorporated in the distributor, and the sowing rate can be varied by changing the gear of the tractor. Thus, three speeds of the tractor gear, combined with the fertiliser gearbox, will give twelve different sowing rates. The conveyor belts are secured in their working position by two handles. By lifting these handles, the conveyors can be easily folded for transport or to permit passage through gateways. In the folded position the width of the distributor is 8ft 3in. Before mounting on the tractor, the distributor rests on four retractable legs. It is therefore only necessary to back the tractor to the distributor, and make the required connections with the hydraulic lift arms and the power take-off shaft. The use of the hydraulic pump is not required to raise the machine to its working position. With a sowing width of 24ft it is, of course, only necessary for the machine to travel 605 yards to deal with 1 acre of land.

Mackay Industrial Equipment, Ltd.

The exhibits of Mackay Industrial Equipment, Ltd., Faggs Road, Feltham, Middlesex, consist mainly of tractors and equipment for land reclamation and heavy contracting work. Among them is the Fiat "55L" industrial tractor, which is powered by a four-cylinder, four-stroke, Fiat diesel engine of 6546 c.c. capacity. At a governed speed of 1400 r.p.m. this engine develops 55 b.h.p. and 44 d.h.p., the maximum drawbar pull of 12,400 lb being obtained at an engine speed of 600 r.p.m. Direct injection is effected through four-hole injectors fed by a Bosch pump which incorporates a centrifugal governor and suction lift pump, and pressure-fed lubrication is provided for by two gear pumps mounted front and rear in the crankcase.

To assist starting there is a 10 h.p. auxiliary petrol engine which builds up the full pressure of the forced feed lubrication system before starting the main engine. The heat from this auxiliary engine initially warms the main engine through the common cooling system. Transmission is through a single plate clutch, there being provision for five forward speeds between 1·4 m.p.h. and 5·2 m.p.h., and a reverse speed of 1·8 m.p.h. The entire transmission system is housed in a heavy duty cast iron casing, all the gear shafts being supported by heavy duty ball and roller bearings. The gauge of the tracks, centre to centre, is 4ft 11in and the width of the standard track shoes is 17¾in, the ground pressure being 4·67 lb per square inch. Steering is by multiple disc clutches controlled by levers. Independent foot pedals actuate the brakes, which can also be applied by a hand lever when parking. The minimum turning radius for the tractor is stated to be 7ft 2in.

An example of the Fiat "55L" fitted with a Mackay hydraulic angledozer, is illustrated in Fig. 8. A tractor with this equipment and with a Boughton heavy duty winch—as described in our last issue—is on view at Earls Court. The Mackay angledozer has a blade measuring 9ft 4½in wide by 2ft 3in high, the cutting edge being ½in by 6in by 7ft 6in, and the maximum tilt 12in. The angledozer can be lifted 2ft 7in above the ground, hydraulic pressure being provided by a constant displacement gear pump working at 1400 r.p.m., with a capacity of 28 gallons per minute. The double acting rams have solid drawn cylinders, and control is by a spring-loaded piston valve which is housed in a cast body and protected by seals. The angledozer blade is carried in the centre by a swivel joint and at the sides by push beams.

Another exhibit on this firm's stand is the "Merton" overloader which was described in our issue of October 31, 1952.

H. Leverton and Co., Ltd.

At the National Power Farming Conference in March, 1952, a paper was presented by Dr. H. von Hülst on "German Agricultural Machinery Design." In it he dealt with the development of "implement carriers," mentioning in particular the recent products of Heinrich Lanz. A new machine of this class is shown on the stand of H. Leverton and Co., Ltd., Spalding, Lincs. It is the Lanz "Alldog" tool carrier and is illustrated in Fig. 9. The engine and transmission are combined with the rear axle and, as will be noted from our illustration, in the front there is a tubular frame to which many different implements can be easily attached. This arrangement, of course, gives the driver a front view of the work being done. The machine itself weighs just over 1 ton, its overall length being about 12ft, and the maximum width 7ft 2¼in. The power unit is a 14 h.p. single-cylinder diesel engine, with a maximum speed of 3000 r.p.m. Power is transmitted through a single dry plate clutch, there being provision for five forward speeds between 1·6 m.p.h. and 12 m.p.h., and a reverse speed of 2·4 m.p.h. The rear wheels are fitted with individual foot brakes which can be locked by a hand lever. The normal equipment of the "Alldog" includes two power take-off shafts, one at the front and another at the rear of the engine. They can be engaged individually and run at a speed of 540 r.p.m. There is also a hydraulic power lift and, if required, a belt pulley, 8½in diameter and 5⅞in wide, and running at 140 r.p.m., can be fitted.

Among other Lanz products which are being exhibited on this stand are a power take-off driven self-binder with 6ft or 7ft cut, a side delivery hay rake and swath turner and a straw baler. A Leverton toolbar is also being shown. It is fitted with three ridger bodies and can be mounted centrally on the tool carrier described above.

Bamfords, Ltd.

This year, Bamfords, Ltd., Uttoxeter, Staffs, has produced a new automatic pick-up baler, a photograph of which is reproduced in Fig. 10. It has been designated the "BL60" and forms rectangular bales 16in by 18in by 36in or 42in. A point which the makers emphasise concerning the machine is the relatively small number of working parts. The baler which is exhibited at Earls Court is powered by an Enfield two-cylinder diesel engine, though petrol or tractor vaporising oil engines can be fitted if desired. The drive is taken through gearing direct to the crankshaft, and from there to the feed reel and auger, pick-up and knotter. There are only four chain drives.

The knotting mechanism incorporates specially designed twine fingers which swing backward during the tying operation and provide sufficient slack in the twine to form the knot. An automatic bale tension bar is fitted in the centre of the top of the baling chamber. It is angled downward in front of the chamber, which causes the greatest tension to be exerted on the foremost bale in the chamber, that is, the one being formed and tied. Three dogs in the top and bottom of the chamber hold the crop tightly together while the plunger returns to the front of the baler for a new charge. The material being dealt with is thereby held under compression even when the plunger head is not actually packing it. The pick-up drum is 5ft wide and is spring counter-balanced so that it becomes quickly adjusted to any inequalities in the ground on which the machine is being worked. The various safety devices which are incorporated in the machine include shear pegs on the flywheel and sweep fork arm, overload clutches on the pick-up and auger drives, and a safety lock on the plunger to guard against broken needles. The baler is operated by rope control from the seat of the tractor which hauls it, and the drawbar can be adjusted to left or right to swing the baler into line with the tractor when passing through gateways or along narrow lanes.

In addition to examples of its mid-mounted and trailed grass mowers and other implements, Bamfords, Ltd., is exhibiting its "Z" series of direct injection diesel engines. The latest models in this series are 5½ b.h.p., 14 b.h.p. and 16 b.h.p. engines. Another engine which the firm has lately introduced, and which is shown on its stand, is a 1½ b.h.p. hopper cooled tractor vaporising oil engine. It is a single-cylinder engine, 3¼in bore and 3¼in stroke, running at 700 r.p.m. This engine is one of a series of small power units, in sizes up to 5 b.h.p., intended for general farm and various industrial purposes.

Arthur Lyon and Co. (Engineers), Ltd.

The "Alco" combined a.c. generator and pump, illustrated in Fig. 11, has been produced by Arthur Lyon and Co. (Engineers), Ltd., 42–44, Telford Way, Acton, W.3, with the lighting and pumping needs of remotely situated farms, small holdings, caravans or houseboats specially in mind. Power for driving the generator and pump is provided by a Villiers "Mk. 10," single-cylinder, 98 c.c., air cooled petrol or petrol-paraffin engine. The engine is flexibly coupled to the alternator which is self-exciting and self-regulating, and is continuously rated for an

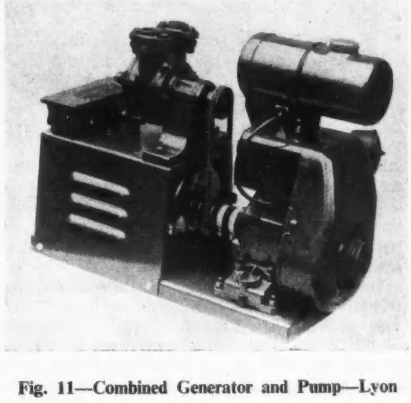


Fig. 11—Combined Generator and Pump—Lyon

output of 500W, 230V, single phase, 50 cycles, at a governed speed of 3000 r.p.m. Main fuses and output terminals are provided. A 1in self-priming centrifugal pump is mounted above the generator. It has an output of 500 gallons an hour and a maximum suction lift of 27ft. The pump is belt-driven from a pulley on the alternator shaft extension and by releasing the belt the pump can be disconnected from the main drive. The pump and generator can thus be operated individually or together as required. The installation needs only a limited space, the dimensions of the outfit being 27in long, 13in wide and 20½in high. It is mounted on a sturdy bed-plate, the weight, we are informed being about 132 lb.

Jack Olding and Co., Ltd.

A fertiliser distributor giving a placement width of 12ft 3in is a new machine shown by Jack Olding and Co., Ltd., Hatfield, Herts. It is known as the "Wilmo" ten-disc distributor, and is equipped with a rotating feed-box which can be swung round to facilitate road transport or passage through gateways. By this arrangement the minimum width in the transport position is 7ft 5in.

Another exhibit on this stand is a grain or seed cleaning machine, known as the "Unidresser," which has been designed for use with a triple elevator. Both are manufactured by Robert Boby, Ltd., Bury St. Edmunds, and Fig. 12 illustrates a combined installation. In the hopper at the top of the "Unidresser" a roller feeder is incorporated to ensure that the grain flows over the full width of the cleaning screens. The grain is first passed on to two reciprocating screens which deal with the larger impurities. It passes through these screens to a third screen, the purpose of which is to remove dirt and small weed seeds which, in turn, are led into an offal spout. The clean grain then flows over a fourth screen which separates the thin kernels from the best sample, and the mesh of this last screen can be altered to control the quality of the final sample. A blower, with its air intake controlled by side shutters, removes the large impurities from the two upper screens and assists the grain to fall in a steady and continuous flow. On the bottom screen there are adjustable brushes which are brought into operation when the machine is used as a final dresser.

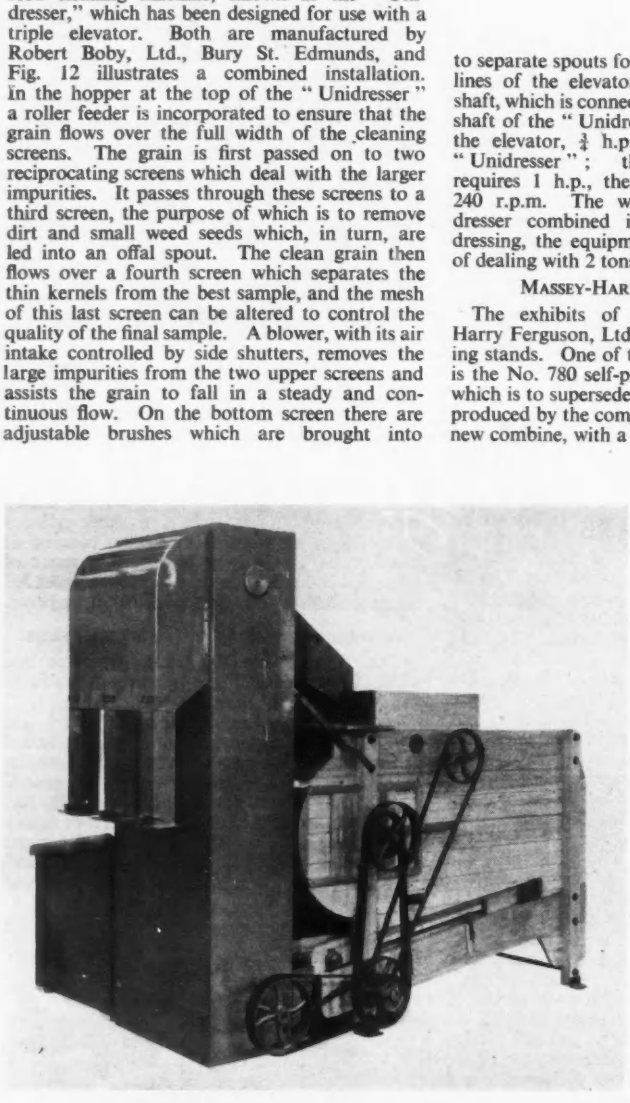


Fig. 12—Boby "Unidresser"—Jack Olding

The triple elevator, which has been designed for use with the "Unidresser," requires headroom of only 7ft 3in. It is provided with a hopper from which the grain is fed by bucket line into the cleaner. Two further bucket lines elevate the tail corn and finally cleaned grain to separate spouts for sacking. The three bucket lines of the elevator are driven from a single shaft, which is connected by a pulley to the driving shaft of the "Unidresser." If operated without the elevator, ¾ h.p. is required to drive the "Unidresser"; the combined equipment requires 1 h.p., the driving shaft speed being 240 r.p.m. The weight of the elevator and dresser combined is 13¼ cwt, and, for final dressing, the equipment is stated to be capable of dealing with 2 tons of grain an hour.

Fig. 13—12ft Combine Harvester—Massey-Harris

Massey-Harris-Ferguson, Ltd.

The exhibits of Massey-Harris, Ltd., and Harry Ferguson, Ltd., are shown on two adjoining stands. One of the Massey-Harris machines is the No. 780 self-propelled combine harvester, which is to supersede the No. 726 model hitherto produced by the company. A photograph of the new combine, with a 12ft cutting width, is reproduced in Fig. 13; the machine is also available with cutting widths of 8½ft or 10ft. A Newage Austin six-cylinder tractor vaporising oil engine is installed, developing 56 b.h.p. at 1940 r.p.m. Alternatively, a Perkins "L4" four-cylinder diesel engine can be fitted, giving 61 b.h.p. at 1940 r.p.m. There are twenty-four variations in the land speed range of the combine between 1 and 7 m.p.h. The equipment of the machine includes a rasp bar cylinder 22in diameter and 32in wide, with eight bars, the standard sprockets giving speeds of 790, 900 and 1040 r.p.m. Separation of the grain is effected by four straw walkers 86½in long and 37in wide, with a surface area of 3194 square inches, and by adjustable sieves which provide a surface area of 2222 square inches. There is a grain tank of 45 bushels capacity, and a four-spout bagging attachment is provided with a rotary screen.

The Ferguson exhibits, in addition to the company's agricultural and industrial tractors, consist of examples of mounted implements. A new machine for use with the Ferguson tractor is a medium pressure sprayer, the booms of which give a total working width of 21ft 6in. The sprayer is fitted with a 92-gallon corrosion-resistant tank and a twin-cylinder piston pump driven from the power take-off shaft. Provision is made for three-stage filtration of the spray liquid.

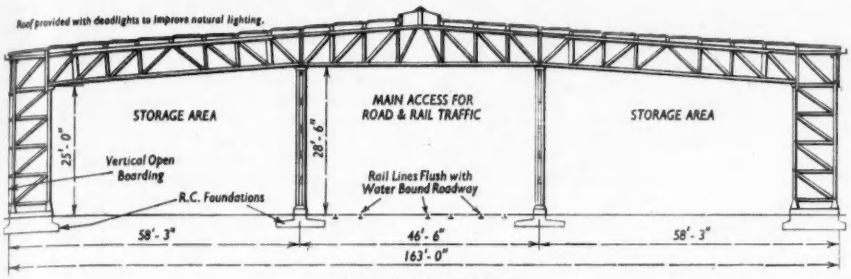
Salopian Engineers, Ltd.

Among the many implements and other items of farming equipment exhibited by Salopian Engineers, Ltd., Prees, Salop, is the "Cheshire" trench digger shown in Fig. 14. This machine, which is of quite small overall dimensions, is capable of digging a trench 6in wide and up to 36in deep in a single cut, is manufactured by Salopian Engineers, Ltd., under an agreement with the Cheshire Engineering Company, Ltd. One man only is required to operate the digger, which is mounted on a four-wheeled chassis. The two front wheels are steered, and the two rear wheels, which are provided with land-grip pattern tyres, are used for propelling the machine by means of a hand-operated ratchet. A Villiers 6 h.p., air-cooled petrol engine mounted at the front of the machine transmits power, by vee belts, to the excavating buckets, which are self-emptying and which convey the spoil to a delivery chute. This delivery chute can be fitted to either side of the machine so that the spoil can be deposited on either or both sides of the trench. For controlling the trenching depth there is a hand-operated hydraulic jack, which raises and lowers the buckets. For easy transport from one site to another, the "Cheshire" digger can be loaded by hand on to any 10-cwt carrier.

Fig. 14—Trench Digger—Salopian

Timber Storage Shed

We have received from the Timber Development Association some details of a large storage shed which has recently been erected for Horsley, Smith and Co., Ltd., on a site in the docks at Hull. The new shed is 440ft in length, 163ft in width and has clear, unrestricted height throughout of 25ft, with fourteen internal columns 55ft apart. Its general design may be observed from the cross-sectional sketch. The area covered by the shed is 1¾ acres. It was designed in accordance with the code of practice CP.112, "The Structural Use of Timber in Buildings," using Douglas fir graded for working stresses of the order of 1200 lb per square inch. Our second illustration shows the progress of erection after some five weeks' work; the main girders of 58ft span over the stacking areas may be noted, as well as the 55ft span secondary girders which are at 6ft 3in centres and act as trussed purlins carrying reinforced troughing as the roof covering. The column bases are of reinforced concrete, extending to a minimum of 12in above ground level to prevent water being held against the timber columns. The constructional timber required was 46·4 standards per covered acre, totalling seventy-nine standards for the complete shed, with the exception of the side cladding.

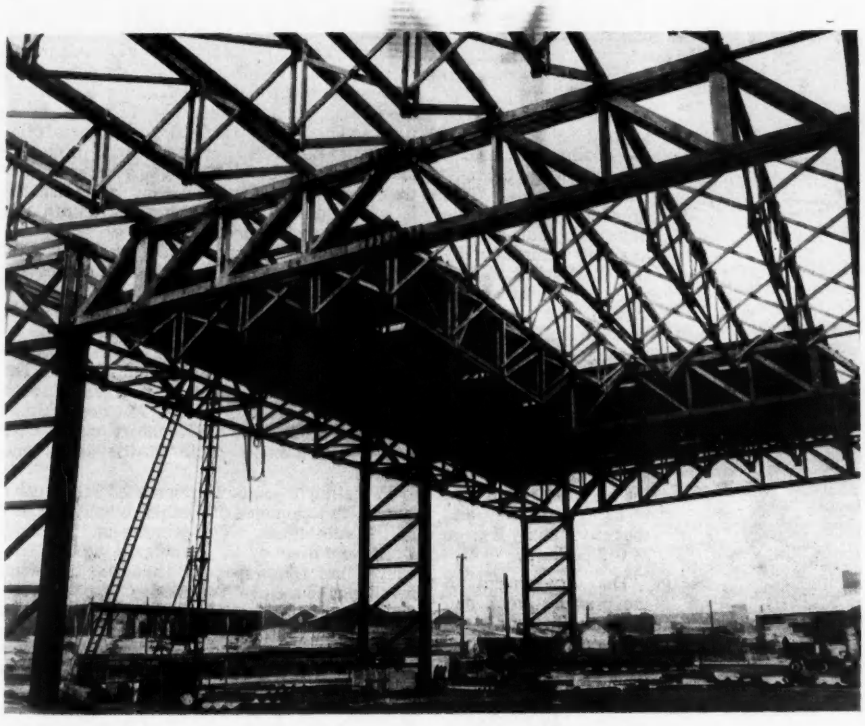


Cross Section of Shed

The cost of the shed was estimated to be 3½d. per cubic foot. One of the chief factors allowing economical erection was the repetitive form of construction adopted. The columns, main beams and purlin sections were erected by crane, the columns taking an average of 20 minutes each from lifting to plumbing and securing, the main girders taking an average of fifteen minutes each. The column and roof sections were fabricated at the suppliers' works.

The T.D.A. points out that in the corrosive sea air and the industrial atmosphere of the site a steel structure would require painting every four or five years at an estimated cost of £1500. The timber shed, on the other hand, the T.D.A. says, will not require painting or other maintenance costs, and it was found that building costs were as economical as those of a comparable steel building. As regards fire resistance, the T.D.A. says there was no hesitation in using timber, since the shed could withstand a fire of intensity two and a half times as great as would cause the collapse of unprotected steel and five times as great as would cause the collapse of aluminium alloy.

The detailed design of the shed was prepared by Boltwood Engineering, Ltd., who also prefabricated the timber units; the architects were Gelder and Kitchen and the building contractors Houlton and Grant, Ltd.

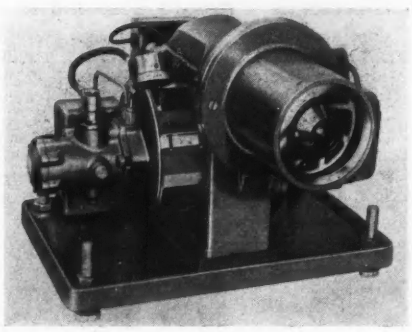


Erection of Shed in Progress

Automatic Oil Burners

Particulars of a new range of pressure jet automatic oil burners, suitable for use on boilers rated between 75,000 and 600,000 B.Th.U. per hour, have been issued by the Brockhouse Heater Company, Ltd., West Bromwich, Staffs. These burners are made in three models and are designed to burn gas or diesel oils having a viscosity not exceeding 70 seconds Redwood No. 1 at 100 deg. Fah.

A burner unit of the new design can be supplied with a bedplate as illustrated here, or with a suitably drilled nozzle flanged for direct mounting on to a furnace front. Each unit is supplied complete with automatic controls.



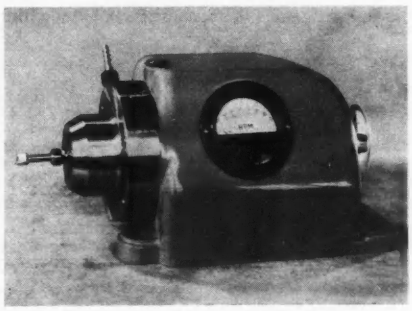
Automatic Oil Burner

The combustion head incorporates means of adjustment by which the correct volume of air for any required duty can be introduced at the optimum velocity to give good combustion.

The burner is driven by a ¼ h.p., 1425 r.p.m. motor and its fuel supply unit, comprising strainer, gear pump, pressure regulating and shut-off valve, is mounted on one side of the assembly. To give a rapid and positive cut-off of fuel at the nozzle a solenoid valve is fitted in the circuit. When the burner motor is switched off the delivery port of the fuel pump is freely connected to the suction port. When the motor is switched on the solenoid valve is energised simultaneously and it closes to isolate the suction and delivery ports of the fuel pump. The pump then delivers oil at the preset pressure to the burner nozzle, surplus fuel being bypassed at the pressure regulating valve. When the supply of current to the motor is switched off by the thermostatic controls during operation of a boiler the solenoid valve is de-energised and opens to effect an immediate pressure drop in the oil line. The rapid cut-off of oil supply to the burner nozzle obviates dribble and any objectionable boiler pulsation whilst the motor blower and pump come to rest.

High-Speed Grinding Spindle

A compressed-air-driven high-speed grinding spindle unit which is now being made by Ulvsunda Verkstäder Akt. of Bromma, Sweden, is illustrated below. This unit is designed to run on a constant air pressure and has a spindle speed range from 60,000 to 100,000 r.p.m. The maker states that an increased torque is developed at the lower speeds and when the wheel is loaded during the grinding operation the spindle speed drops by about 10 per cent.



Compressed-Air-Driven Grinding Spindle

The spindle is carried on high-precision ball bearings of special design and the races for these bearings are machined directly on the spindle, which also carries the air turbine rotor. An electrically operated revolution counter is fitted. The supply of compressed air is first passed through an integral air cleaner, which also serves to remove any water, and then through an air regulator built into the housing.

Spindle speeds are controlled by the setting of a regulating screw. Grinding wheels up to ⅜in diameter can be used with these grinding spindles, and a range of quills and standard chucks are available.

Pneumatic Pressure Transmitter

Our illustrations show a pneumatic pressure transmitter which is designed to convert a static or differential pressure into a pneumatic output pressure for the operation of a local or remote indicator or controller. It is known as the "Drimac" pneumatic pressure transmitter and is made by Elliott Brothers (London), Ltd., Century Works, Lewisham, S.E.13. As described below, the transmitter constitutes a means of

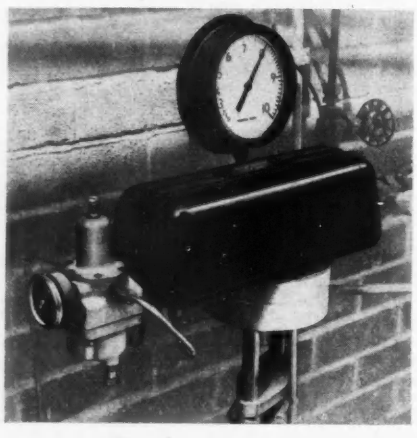


Fig. 1—"Drimatic" Pneumatic Force-Balance Transmitter

balancing input pressure ranging from 0·05in w.g. to 700in w.g. and delivering output pressures of 3 lb to 15 lb per square inch.

The principle of operation is outlined in the accompanying schematic diagram. The input pressure-measuring element is either a diaphragm or metallic bellows and the force that it produces is shown in our diagram (Fig. 2) by an arrow to the right of the cross spring pivot. Movement of this input-pressure-measuring element is transmitted to a statically balanced weigh-beam. The right-hand end of this pivoted beam thus moves towards or away from a throttle or nozzle connected to the air supply and this movement varies the nozzle pressure. Air at the nozzle pressure operates a balancing diaphragm which (through the medium of an auxiliary pivoted beam) acts on the main beam in opposition to the input element. Under the action of the two opposing forces the weigh-beam is restored to its original position : the balancing diaphragm pressure (that is, the nozzle pressure and the transmitted signal pressure) is proportional to the input signal. In this instrument, therefore, differential pressure converter, and the desired result in the case of the "Drimac" instrument was achieved by a system of crossed leaf springs for the suspension of the main weigh-beam and a similar system for the auxiliary beam. In Fig. 3 part of the forked weigh beam is cut away to show the main pivot crossed leaf springs. The crossed spring pivot of the auxiliary beam can be seen towards the right hand of Fig. 3. This drawing also shows the adjustable nut on the auxiliary beam whereby the mechanical advantage of the weighing system and the ratio between the input signal and the output pressure of the transmitter can easily be varied between the limits of 1 : 1 and 7 : 1. The ratio adjustment can be done on site. The sensitivity of the transmitter is stated to be 0·1 per cent and the zero stability is given as 0·3 per cent.

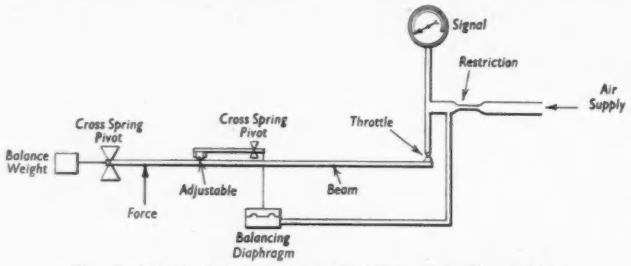


Fig. 2—Schematic Arrangement of "Drimatic" Transmitter

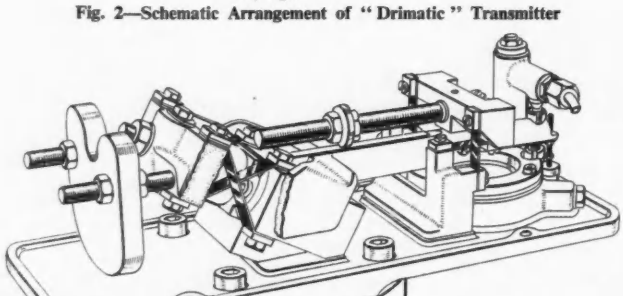


Fig. 3—"Drimatic" Transmitter Showing Cross Spring Mountings

The arrangement of the pressure block and the ligament connection between the pressure-measuring element and the weighing system is shown in Fig. 4. The pressure block itself is machined from solid steel and is sealed by a metallic bellows. It is designed for working pressures up to 1500 lb per square inch. The absence of glands and stuffing boxes implies the elimination of maintenance and friction in this part of the mechanism.

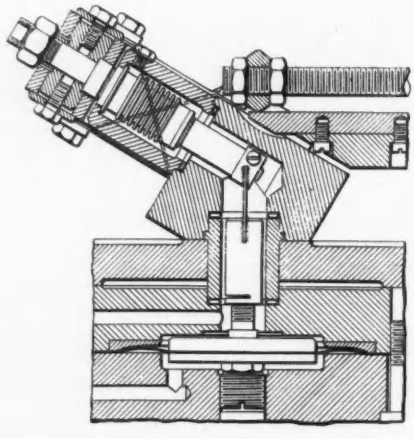


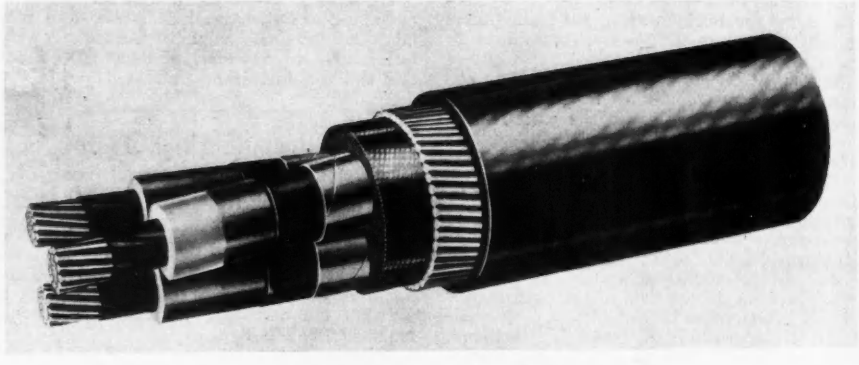
Fig. 4—Arrangement of Pressure Block

The complete weigh-beam and nozzle assembly is mounted on a base-plate, which is fitted directly to the chamber containing the measuring element, as can be seen from Fig. 3. Normally, this chamber is made of mild steel, but, if required, the chamber and all parts in contact with the fluid can be made of stainless steel.

As illustrated in Fig. 1, the "Drimac" transmitter is fitted with a cover of cast aluminium alloy which is secured from the bottom of the base-plate. All connections are made from below the base-plate. A bracket is provided to carry a Fisher "67FR" combined filter and pressure regulator for the air supply. In Fig. 1 the transmitter is shown fitted with a local indicator, installed at an oil refinery.

Polythene-Insulated 11kV Power Cable

A power cable with polythene insulation was recently installed for the Manchester Ship Canal Company by the No. 3 Sub-Area of the Merseyside and North Wales Electricity Board. An extension to the Board's mains was required for the new oil dock at Eastham, near the Mersey entrance to the Ship Canal and the necessary connection was provided by laying an 11kV cable between the company's substations Nos. 2 and 3, situated on opposite sides of the lock which gives entry to the oil dock.



Polythene-Insulated 11kV Power Cable

The cable used for this connection was manufactured by The Telegraph Construction and Maintenance Company, Ltd., Telcon Works, Greenwich, London, S.E.10. It is an 11kV, 0·1 square inch, three-core, screened cable which is polythene insulated, wire armoured and served, the build of the cable being as illustrated herewith. Because the insulating material is impervious to water a metallic sheath was considered to be unnecessary.

A low-level subway, served by two vertical shafts, passes under the lock and carries the electric, hydraulic and other services.

The cable was installed in three lengths totalling about 360 yards. On each side of the lock a length of cable was laid direct in the ground between the lock side and substation. The middle length of cable was taken through the 135ft long subway via the 70ft deep vertical shafts at each end. Greenheart cleats were used to secure the cable in the shafts and subway.

Two straight joints were included in the cable run which terminated at oil-filled circuit breakers in the substations. The jointing and terminal work were done by the manufacturing company which has developed a suitable technique involving the use of "Telcohesive" tape whereby the insulating and non-hygroscopic qualities of the cable are reproduced in the joints.

Coastal Minesweeper "Kemerton."—Her Majesty's coastal minesweeper "Kemerton" was launched on November 27th at the Belfast yard of Harland and Wolff, Ltd. The ship has a length of 152ft by a beam of 28ft 9in and will be armed with three small guns.

Power Shovel and Loader

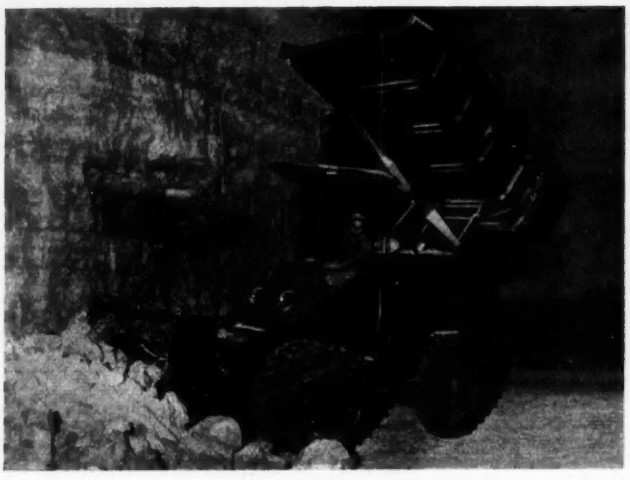
A RANGE of hydraulic power shovels being made in France by the Société Française de Construction de Bennes Automatiques, 57, Avenue Kléber, Paris, 16, is now available with an overhead combined "chute-hopper" unit, which facilitates and speeds the work of loading. In normal practice mobile loading shovels are driven into the material to be loaded and after the full bucket has been raised the unit is manœuvred to deposit the load in a transport vehicle. This manœuvring often takes up a fairly high percentage of the working time, and the new equipment has been developed to reduce this time to a minimum. A photograph we reproduce on this page shows a shovel fitted with the new equipment, which is known as the "Retro-Loader."

When using a shovel fitted with the overhead equipment the transport vehicle into which the material is to be loaded is placed a short distance behind the machine. The shovel then shuttles backwards and forwards in a straight line to cover the shortest possible distance between the stockpile and the transport vehicle.

The equipment is made in two forms. In one design the chute-hopper is mounted on hinged arms actuated by hydraulic rams. In the other design, illustrated here, the hopper-chute is fixed.

When using the first form of machine its bucket is filled in the usual way by driving the machine into the stockpile. The machine is then backed and whilst it is moving the filled bucket is swung upwards by hydraulic power. During this operation the hopper is in its rearwards, tipping, position and when the bucket has been swung up through about two-thirds of its stroke the hopper hydraulic system becomes effective and moves it forwards into its vertical position. The bucket has a hinged side and when it registers over the hopper this side automatically opens to deposit the material into the hopper. The machine has by this time reached its rearmost position by the transport vehicle and as the hopper is then swung back it tips to discharge the material it contains into the vehicle. The bucket is then lowered and the machine driven forwards for the next filling operation. With this machine material can be discharged at heights of up to 15ft.

A machine fitted with fixed hoppers can be used for discharging material at heights of up to 8ft, and one can be seen in operation in the illustration. The hopper in this case is set at an angle and is of larger capacity than the bucket, and it is fitted with a door at the rear, which is actuated by hydraulic rams. In operation a bucket is filled and, after the machine has been driven back a short distance, the bucket is swung up and its load deposited in the hopper. The bucket is again lowered and filled before the machine is driven right back to the transport vehicle. The door of the hopper is then opened and when the material it contains has been deposited the bucket is swung right up to shoot its load into the hopper to gravitate down into the truck. During unloading the power-operated door of the hopper can be used to assist in distributing the load in the vehicle.



Power Shovel and Loader in Operation

Air Compressors

ONE of nine large air compressors designed and built by the Atlas Diesel Company of Stockholm, Sweden, for the National Coal Board has been placed in service at the Mountain Colliery in South Wales, and is to be seen in the illustration below. This compressor, like eight others being supplied to the order, is driven by a 540 h.p., 300 r.p.m., flywheel type synchronous motor, the rotor of which is mounted directly on the extended crankshaft of the machine. With this design the need for an outer bearing or coupling between the motor and compressor is eliminated, and not only is installation work simplified, but much less foundation space is required for a [illegible] machine. With a compressor running at 300 r.p.m. the free air delivery at 100lb per square inch is 3220 cubic feet per minute, but the output of the N.C.B. compressor is regulated to 80 lb per square inch, the standard pressure used in collieries in South Wales.

The compressor is of two-stage, double-acting design with a vertical low-pressure cylinder and a horizontal high-pressure cylinder. An inter-cooler with two water-cooled elements is fitted in the angle between the two cylinders to give a compact arrangement without affecting the degree of accessibility for maintenance purposes.

The crankcase is cast in one piece complete with crosshead guides. A forged alloy steel crankshaft is fitted with counterweights for balancing purposes and is carried in self-aligning, spherical roller bearings. The connecting-rods have detachable big end bearings of cast steel, with cast-in white-metal linings, and the small ends are fitted with bronze bushes for the gudgeon pins.

Each crosshead is a steel casting fitted with detachable white-metal-lined shoes, and their gudgeon pins, of case-hardened steel, have ground conical ends for fixing purposes. Cast iron pistons are fitted—that in the low-pressure cylinder having two rings and that of the high-pressure cylinder three rings. The piston rods are secured to the pistons by taper and screw fittings; they are sealed by stuffing-boxes fitted with cast iron rings. Scraper rings under the stuffing-boxes serve to remove lubricating oil and prevent it seeping into the cylinders.

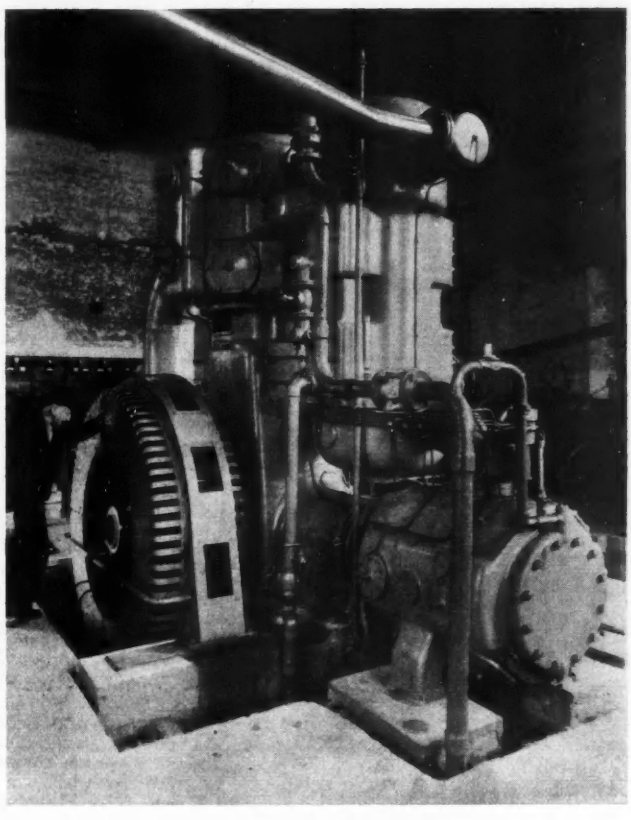
The ring valves fitted to the compressor have a number of concentric plates, and at both the inner and the outer chambers they are positioned within the cylinder body. Buffer plates are fitted above the valve discs to reduce their impact on the valve guards. Springs set in recesses in the guards press the valve plates against their cast iron seats.

The compressor has a means of regulation by which a gradual reduction in capacity is effected by the opening of special unloading valves. These valves connect the cylinder chambers with clearance pockets in the cylinder walls and during the compression stroke when they are open a portion of the air is forced into a clearance pocket instead of being discharged through the delivery valve. Each chamber has two unloading pockets, which can be connected for either half or full unloading. With this arrangement unloading the compressor can be effected in four steps to give full, three-quarter, half and one-quarter loadings respectively. The regulating valve is operated by compressed air from the air receiver and it has a main plunger which regulates the supply of air for operating four auxiliary plungers. Each plunger in turn distributes the air to its respective unloading piston.

The regulating valve can be adjusted to give a pressure difference of 3 lb per square inch between the unloading steps so that the total pressure difference between full load and no load amounts to 11 lb per square inch. With this method of unloading a compressor by clearance pockets high efficiency is given during part-load operation, and the load on the bearings and reciprocating parts is balanced during unloading.

Safety devices are arranged to give warning or to stop a compressor if the lubricating oil pressure drops below a safe level, or if the cooling water supply is too low or its temperature rises appreciably.

Lubricating oil is circulated through the compressor by a gear pump coupled to one end of the crankshaft and drawing oil via a filter from a sump in the bottom of the crankcase. This pump delivers oil through the centre of the crankshaft and oilways through the connecting-rods, to the big end and gudgeon pin bearings and the



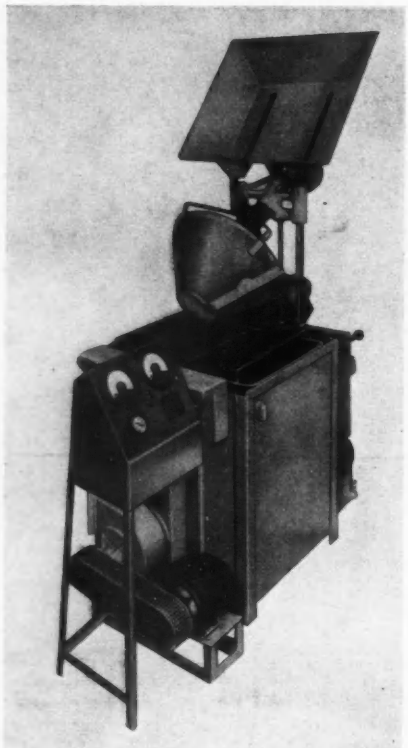
Air Compressor Installed at a Colliery

sliding surfaces of the crossheads. The cylinders are lubricated by a force feed unit driven from the crankshaft through a worm gear. The cylinders and cylinder heads are water cooled and the flow of water is controlled by a thermostatically controlled valve on the discharge side of the system.

Small Chrome Plating Barrel

A COMPACT chrome plating barrel equipment for handling bulk quantities of small components, which is now being made by W. Canning and Co., Ltd., Great Hampton Street, Birmingham, 18, is illustrated below. The self-emptying conical barrel fitted to the equipment has a capacity of from half to three-quarters of a pint of articles and is driven by a small geared motor unit.

The barrel, complete with its drive and a hinged hood, is supported by a substantial bracket member on two vertical pillars at the side of a water-jacketed, lined, tank. This



Chrome Plating Barrel

barrel assembly is movable up and down the pillars by a hydraulic lifting unit at the rear of the tank. In the illustration the barrel is shown raised with the hood hinged back for the loading or swilling of the barrel. When the assembly is lowered the barrel is immersed in the tank and the hood provides an effective protection. The fumes are exhausted by a self-contained fan unit from a duct formed in one top edge of the tank. The usual control instruments are conveniently grouped on a panel at the side of the unit.

Corrosion Voltmeter

As corrosion is essentially an electro-chemical process it follows that some means of measuring the electric potential between a buried ferrous structure and its surroundings is needed in any assessment of the corrosive action on the structure. A corrosion voltmeter for this sort of work has been developed by the Cambridge Instrument Company, Ltd., 13, Grosvenor Place, London, S.W.1, in conjunction with Cathodic Corrosion Control, Ltd.

The corrosion voltmeter differs from voltmeters of normal design in that it embodies a potentiometer which, in effect, feeds into the "corrosive circuit" an e.m.f. equal and opposite to the corrosion e.m.f. Because these two e.m.f.s are equal and opposite no current is taken from the corrosive circuit between the structure and the soil—an essential condition for the accurate measurement of the small electrical potential involved.

The instrument consists of a high-resistance "Unipivot" voltmeter with two ranges (0V to 1·2V and 0V to 5V) and a potentiometer which is connected in series with the corrosion-voltage circuit. After making this connection the potentiometer is adjusted until the voltmeter reading is zero. The backing-off voltage of the potentiometer is then measured on the voltmeter and this reading is equal to the e.m.f. developed between the structure and the soil. The maker states that, with care, measurements can be made satisfactorily in circuits up to 1 megohm resistance.

When used as a direct-connected voltmeter the resistance of the instrument is 50,000 ohms on the 1·2V range and 208,000 on the 5V range. The current corresponding to full-scale deflection is 24 micro-amperes. A self-contained dry battery supplies the current of about 10 milliamperes that is required for the potentiometric circuit. The complete instrument is housed in a reinforced plastic case which is fitted with a hinged lid and a carrying handle and is designed for field use.

Plate-Girder Bridges*

BY G. ROBERTS, M.I.C.E., and O. A. KERENSKY, M.I.C.E.

Defects in design, in welding far more than in riveting, may increase the difficulties and cost of fabrication and erection to such an extent as to outweigh the economy arising from saving in material. In addition to reviewing present practice and the problems associated with welding work, the authors have attempted to indicate the lines that a design should follow to achieve real economy.

Girder Sections.—A simple I-section is the most suitable for welded construction. The material can be disposed more effectively than with riveted construction as flange angles are not required, tension flanges need not be increased in area to compensate for rivet holes and more rigid stiffening of the web can be provided, with lighter sections of the stiffeners.

Judged on cost per ton, the cheapest form of girder is one with parallel flanges of constant size and an unstiffened web of uniform thickness, but the economic range of such a section is limited. As the size and span of the girder increase, the saving in weight of steel achieved by changes in thickness of flange and web, and the introduction of web stiffeners, outweighs the increased cost of fabrication.

Design of Web and Economic Depth.—Most current specifications for design of web plates are related to Timoshenko's† critical shear stress, i.e. stress which would cause buckling. Bergman and others have shown that a small amount of buckling is not detrimental and, in fact, cannot be avoided and that thinner webs than hitherto permitted can be used with safety, provided stresses are appropriately reduced. The draft of the revised B.S. 153 permits a ratio of depth/thickness of 240, with allowable stresses as follows :—For mild steel :

$$F_s = 6\left[1{\cdot}3 - \frac{\frac{b}{t}}{250\left\{1+\tfrac{1}{2}\left(\frac{b}{a}\right)^2\right\}}\right] \text{ tons/in}^2$$

but not greater than 6 tons per square inch.
For high-tensile steel :

$$F_s = 8{\cdot}5\left[1{\cdot}3 - \frac{\frac{b}{t}}{200\left\{1+\tfrac{1}{2}\left(\frac{b}{a}\right)^2\right\}}\right] \text{ tons/in}^2$$

but not greater than 8·5 tons per square inch where

a = the greater unsupported clear dimension of the web in a panel ;
b = the lesser unsupported clear dimension of the web in a panel, and
t = the thickness of the web.

* Abstracts. Paper presented at the Conference on Welded Structures, Institution of Civil Engineers, November 26th.
† The bibliography will be found in the original paper.

The economic depth of web, i.e. depth giving minimum weight, is approximately achieved when the weight of the flanges is about equal to that of the web.

Approximate economic depth of girders can be obtained from accumulated design data or by investigation of the particular case. The range is very wide ; from about one-fifth of the span for short mild steel girders (say, 20ft) carrying heavy loading (say, 6 tons per foot) to one-twenty-fifth of the span for long high-tensile steel girders (say, 180ft) carrying light loading (say, 3 tons per foot). Fortunately, only an approximately correct depth is required.

The depth of the web having been decided, its required minimum thickness should be estimated at the ends, and at, say, quarter-points and centre line of the girder with stiffeners at different spacings.

In larger girders thickness of web plate can be varied with advantage. This is particularly true when vertical web splices are required in any case, because of the limitations of sizes of plates.

In deep girders, economy of weight is obtained with stiffener spacing varying from about half-depth at ends to one and a half depths at centre.

In general, webs less than 32in deep should always be designed without intermediate stiffeners ; webs 32in to 54in deep may require intermediate stiffeners ; webs over 54in deep should always be stiffened unless exceptional thickness is required to carry the shear.

Web Stiffeners.—These can be divided into load-bearing and intermediate stiffeners. Load-bearing stiffeners are designed as struts consisting of the pair of stiffeners and a length of web equal, when available, to twenty times the thickness of web on each side of the centre line of the stiffeners, and taking the effective length as 0·7 of the girder depth.

Intermediate stiffeners should be designed primarily to prevent buckling of the web. Moore, Brown and others have shown that very flimsy stiffeners will prevent a slender web from buckling under normal working stresses and that stout webs require a much greater amount of stiffening if further improvement in their carrying capacity is required.

The draft of the Revised B.S. 153 recommends that to prevent buckling of web, the inertia I of the stiffener should not be less than :

$$1{\cdot}5\frac{(dt)^3}{b^2}$$

where

I = moment of inertia of a pair of stiffeners about the centre of the web or of a single stiffener about the face of the web
d = the clear distance between flanges ignoring fillets.
b = clear distance between stiffeners.
t = thickness of web.

If stiffeners are also required to provide lateral support to compression flanges, they must be designed as beams in bending, and the two functions of the stiffeners should be separately provided for.

Welded construction permits the most economical use of material in stiffeners. For the smaller girders, flats welded on edge will often suffice. For larger girders, angles and tees welded at the toe make the best stiffeners. In double-web box girders stiffening is usually provided by internal diaphragms welded on three sides (not to the tension flange).

In riveted work stiffeners are normally attached to the web in pairs, one on each side of web ; in welded construction it is cheaper to use single stiffeners placed alternately on opposite sides of the web. This saves steel and, more important, the amount of welding required.

Flange Sections.—Wherever possible, the flange should be a single section—a universal plate, a channel or even a joist. There is, however, a practical limit to the sectional area that can be provided in this way—about 100 square inches. If a greater flange area is required the balance can be provided by vertical flats welded to the edges of the main plate, by the introduction of a thick plate (flitch plate) into the web next to the flange plate, or by adding further flange plates to the first one as in riveted construction. Fig. 1 shows these various sections. The alternative, of doubling up the plates, is the least

attractive solution. The plate surfaces are not perfectly flat, and, therefore, cannot be in close contact; there is no means of forcing and holding the surfaces together, as with riveting; the only connection between the plates is at their edges.

The outstanding width of an unstiffened flange plate must not exceed sixteen times its thickness (or fourteen times for high-tensile steel) to ensure elastic stability and even distribution of stress. To keep the transverse angular

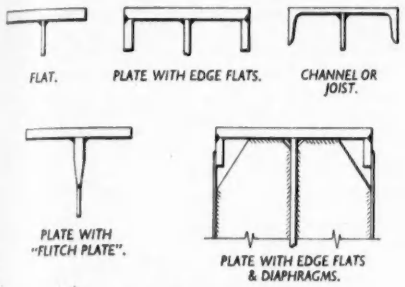


Fig. 1—Flange Sections

distortion of the flange within acceptable limits, however, it is desirable that the width of the unstiffened plate should not exceed $4t/s$, where

t = the plate thickness, and
s = size of fillet welds connecting the web to flange.

This is an empirical rule based on the authors' experience. Alternatively, if the edges of the flange plate are stiffened by vertical flats, or if the flange consists of a rolled channel or joist, the angular distortion may be completely prevented by the attachment of the vertical members to the stiffeners.

If there are no web stiffeners, or if they are stopped short of the flanges, the web thickness should not be less than a quarter of the flange thickness. "Flitch plates" may also be introduced to distribute concentrated wheel loads over a greater length of web than would otherwise be possible. In bridgework the wheel loads including impact do not exceed 20 tons and are usually well distributed by the road or railway

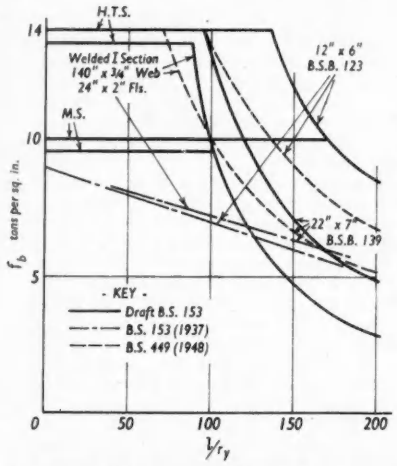


Fig. 2—Allowable Stress in Compression Flange in Accordance with Draft B.S. 153, B.S. 153 : 1937, and B.S. 440 : 1948, for Typical Solid Web Girders

deck, but in crane gantry girders where the wheel loads are very much greater, these "flitch plates" may serve a useful purpose and justify the additional amount of welding required.

Working Stress in Flanges.—It has been shown by calculation and confirmed by experiment that there is no risk of failure by instability of the compression flange (provided the girder is designed to the standard rules as to web thickness, &c.) if the ratio of unsupported length to least radius of gyration l/r does not exceed 90. In that case, the criterion for failure may be taken either as the approach of the flange stress to the yield point of the material (the elastic theory) or the formation of plastic hinges (the plastic theory).

As the ratio l/r increases, elastic instability comes into play and working stresses have to be reduced in "elastic" design, while the "plastic" design method becomes inapplicable. A simplified formula of allowable stresses, based on the work of Timoshenko, Winter, Flint and others, was derived by Flint and Kerensky as follows :—

The bending stresses (calculated on gross section) in the flanges of greater moment of inertia about YY axis shall not exceed

$$f = \frac{100{,}000}{l/r_y}\left[\sqrt{1+\frac{1}{20}(l/r_y)^2(t_e/d)^2+K_2}\right] \text{ tons/in}^2$$

or

$$\frac{\text{yield stress}}{\text{factor of safety}},$$

whichever is the lesser.

Where

l = effective length, in inches, of compression flange (making allowances for the effectiveness of lateral restraints).

r_y = radius of gyration, in inches, of the section about YY axis at the point of maximum bending moment.

d = overall depth of girder in inches, at the point of maximum bending moment.

t_e = effective thickness of flange in inches = $K_1 \times$ mean thickness of the horizontal portion of the flange of greater moment of inertia about the YY axis, at the point of maximum bending moment. The coefficient K_1 allows for the reduction of the thickness and/or breadth of the flanges and depends on N, the ratio of the area of both flanges at the point of minimum bending moment to that at the point of maximum bending moment. Values of K_1 for different values of N are given in Table I (for flanges of constant area $K_1 = 1$).

K_2—coefficient to allow for inequality of tension and compression flanges. This coefficient depends on M, the ratio of moment of inertia about YY axis of the compression flange to that of the whole section at the point of maximum bending moment.

Values of K_2 for different values of M are given in Table II.

Fig. 2 shows a representative comparison of the proposed allowable stresses and those at present in use, and clearly illustrates the economy that will be achieved.

The use of some such formula is particularly important when unequal flanges or flanges of variable sections are being used.

Flanges of Half-Through Bridges.—In the case of half-through bridges provided with U portal frames composed of shallow cross girders and vertical stiffeners, the compression flange can be treated as a strut with elastic lateral supports provided by the U frames. Ignoring the variation of stress along the length of the flange and the additional restraint offered by the web itself, the effective length L of the flanges may be taken as: $L = 2\sqrt[4]{EI a\delta}$, but not less than twice the distance between frames nor greater than the effective span, as defined in B.S. 153, Part 4, Clause 2.

Where

I = moment of inertia of the flange about YY axis of the girder.

δ = the lateral deflection of the compression flange at the frame nearest midspan due to the deformation of the frame only, caused by unit load, applied horizontally to the compression flange.

a = distance between frames

Curved Flanges.—In addition to the visual improvement, the curved flange also gives the satisfying impression that the flange stress is deflected smoothly round the curve instead of being jerked round sharp corners. It is a fact, however, that many failures of welded structures in service have been associated with curved flanges. Where they are introduced, careful attention should be paid to their stability and to the additional stresses produced in the girder.

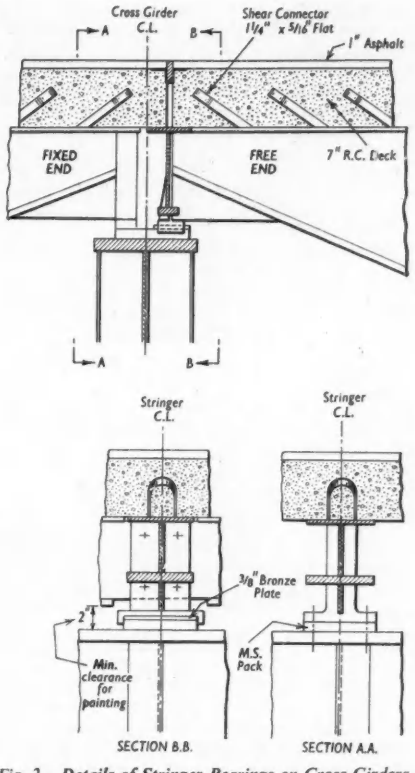


Fig. 3—Details of Stringer Bearings on Cross Girders. Proposed Auckland Harbour Bridge

Direct stress S in a curved flange has a radial component, S/R per unit length where R is radius of curvature. With a reasonably rigid flange this component produces a cross bending stress in the flange which at the junction with the web approximately equals $3SB/4Rt$, where B = width and t = thickness of flange. This cross bending, of course, produces a radial deflection of the flange plate, with consequent redistribution of direct stresses and of radial forces. As a result the direct stress in the flange near the web is increased, which may cause over stressing. The welds between the flange and web are subjected to radial outward or inward forces in addition to longitudinal shear, and these must be properly allowed for. The radius of curvature should be made as large as possible.

Composite Construction.—In deck girder bridges appreciable economy may be obtained by designing the reinforced concrete or steel plate deck as part of the top flanges of the longitudinal girders and cross girders (if any), and by making provision for the distribution of concentrated loads between adjacent longitudinal members, either by the deck itself or by lateral steel members.

In practice, the problem of allocating to each longitudinal beam its correct share of the load is simple if equivalent uniformly distributed loadings are used, but when individual axle or wheel loads have to be provided for, distribution curves developed by various investigators can be used.

If advantage is taken of the combined action of slab and beams in determining the moment of resistance of the girder, it is essential to ensure

TABLE I—*Factor* K_1 *for Deriving Effective Thickness*

N	1·0	0·9	0·8	0·7	0·6	0·5	0·4	0·3	0·2	0·1	0
K_1	1·0	1·0	1·0	0·9	0·8	0·7	0·6	0·5	0·4	0·3	0·2

TABLE II—*Factor* K_2 *to Allow for Inequality of Tension and Compression Flanges*

M	1·0	0·9	0·8	0·7	0·6	0·5	0·4	0·3	0·2	0·1	0
K_2	1·0	0·8	0·6	0·4	0·2	0	−0·2	−0·4	−0·6	−0·8	−1·0

Note.—The stresses in the flange of the lesser moment of inertia about YY axis, corresponding to those given by the formula for the greater flange, shall not exceed $\frac{\text{yield stress}}{\text{factor of safety}}$.

that such action, in fact, does take place. For this purpose "shear connectors" have to be provided throughout the length of the girder. Wästlund recommends as the most efficient type of connector a U shaped round steel bar welded to the top flange of the girder. Z bent flat with skew-cut ends would appear to be preferable for heavy shears, since the length of fillet weld is increased. The connectors should be designed to resist, at high stresses, the whole of the horizontal shear between the steel flange and concrete slab.

For maximum economy the flange to which the deck is connected should be much smaller than the other flange of the girder. The use of welded girders with unequal flanges and welded shear connectors may save as much as 30 per cent in weight of steel. Fig. 3 shows proposed deck for the Auckland Harbour Bridge.

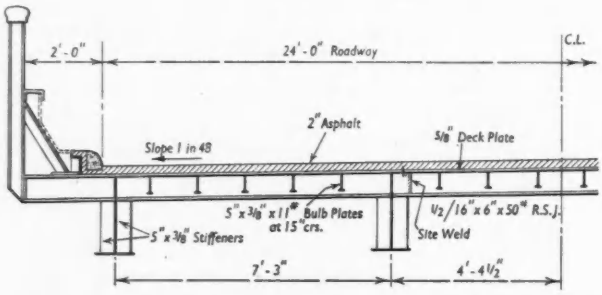


Fig. 4—Half-Section of Steel Plate Deck on Proposed Severn Bridge

The steel plate deck with welded stiffeners becomes economical as compared with a reinforced concrete slab when the maximum saving in weight or in depth of construction is necessary, as in long-span bridges, movable bridges and the replacement of the decks of old bridges required to carry heavier loads.

The deck plate, reinforced as necessary by bulb plates, tees or angles should be welded direct to the web of an inverted T beam, so that the whole forms an I-beam with unequal flanges. In America, the plate is usually connected to the top flange of a rolled joist, but this does not provide the maximum economy in weight. The upper surface of the deck plate should be protected against corrosion and then covered with about 1½in of asphalt, care being taken that all edges are properly sealed. Fig. 4 illustrates the steel plate deck developed for the proposed Severn Bridge (3300ft span).

If steel plate decks are connected to vertical girders at top and bottom flanges the whole acts as a cellular monolithic structure. In certain circumstances such construction may prove economic.

End Connections of Deck Members.—The interconnection of deck supporting members—cross girders and stringers—may be even more troublesome in welded design than with riveting. The tacit assumption of semi-flexibility at riveted joints (since it is known that rivets will slip and angle cleats will bend if overstressed) allows the designer to overlook many secondary stresses—bending and direct—which cannot be neglected in welding. The welded connection must carry the stress to which it is subjected or break.

In deck bridges consisting of a number of longitudinal girders with the deck construction (concrete or steel) connected rigidly to the flanges the problem does not arise, but in half-through bridges, which are frequently used when constructional depth must be kept to a minimum, the connection of cross girders and stringers need careful consideration.

If the deck is above or below the neutral axis of the main girders it will tend to participate in the flange action and the stringers will be subject to direct stress in addition to the bending for which they are usually designed. In completely welded construction this interaction of the stringers with the main girder flanges can be effected by the introduction of lateral bracing or of a steel plate deck. The stringers must then be designed as continuous girders with completely rigid connections and the cross girders are thereby subjected to heavier reactions and probably increased in section. Fig. 5 shows a detail of such a connection.

An arrangement like this is almost certainly uneconomic and it is preferable to allow the main girders and deck to act independently so far as longitudinal stresses are concerned. This can best be done by introducing semi-flexible or expansion joints at the ends of the stringers. Where possible, the stringers should be reduced in depth at their ends and rest on top of the cross girders, one end being fixed to the girder and the other sliding. If the bearings are made narrow they will allow for angular movement due to deflection of the stringer (see Fig. 3).

If the construction depth available does not permit this arrangement, and the stringers must be built into the cross girders, a semi-flexible connection as shown in Fig. 6 is recommended, either riveted or bolted. In this case the T stiffeners must be of exact width and the stringer and plates preferably milled square after welding.

Cross girders usually can be rigidly attached to the main girders since these are sufficiently flexible (or can be made so) to permit the change of slope of the cross girder without overstressing the joint.

Economies in Steel and Cost.—Compared with riveted construction welded plate girders show a saving of at least 15 per cent in weight and probably a higher percentage in total cost, as the fabrication cost for a well-designed welded plate girder should be less than for its riveted counterpart.

Unfortunately, direct comparisons in cost between welded and riveted work are somewhat confused as they are usually influenced, in the case of any one firm, by the availability of suitable plant and labour.

In considering the economy introduced by welding, the designer should have some idea how far he can go in saving weight by increasing the complexity of details before the economy inherent in welded construction is completely lost. The most efficient welded design is in this respect a compromise between the maximum saving in steel and minimum cost of fabrication.

Generally, it is not worth changing the section of flanges in girders of up to 40ft span, and in longer spans flange joints should only be introduced at points where the change in sectional area required is about 50 per cent.

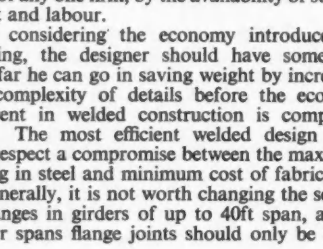


Fig. 5—Stringer Connection for Continuity

Joints in the web are relatively simple to make and may be introduced if required, for variation in section without serious increase in cost, but the number of stiffeners should be cut to the minimum required by the designer, and small brackets, &c., which are not absolutely essential should be studiously avoided.

Shop Fabrication and Site Welding.—It cannot be too strongly emphasised that the accuracy of preparation of material for welding should be at least up to the standard demanded in riveted bridgework; any relaxation inevitably results in an excessive amount of welding, difficulties due to distortion, and usually complete loss of economy. The fact that a gap between butting edges is sometimes specified on working drawings (perhaps with a tolerance of $\frac{1}{16}$in to $\frac{1}{8}$in) appears to give the impression that dimensional exactitude is less important in welded work because the weld "fills up the gap." There should, in fact, be no gaps anywhere and the closeness of fit should be that normally demanded in riveted bridgework. All parts must be accurately cut to length and properly flattened, since in welded fabrication there is no possibility of correcting misalignments by drawing the parts together with bolts or drifts. If the operations of cutting to length, edge planing, &c., of the girder components are properly done, a welded girder can be plated and tacked ready for welding surprisingly quickly and cheaply.

When the flange or the web is composed of several lengths of plate, it is good practice to butt weld the pieces together before assembling the girder.

The parts of the web should be laid flat and butt welded from both sides to form a single plate of the full length. The edges should be planed and closely butted either for the full thickness or on a reduced root face, according to the welding technique.

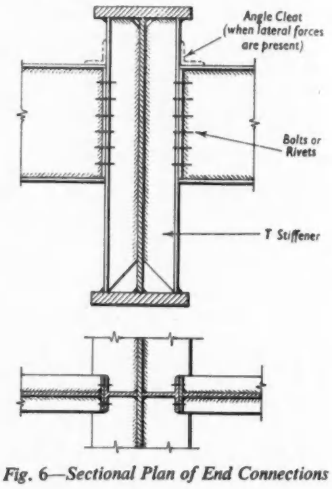


Fig. 6—Sectional Plan of End Connections

It is inadvisable to make the joints in thick and narrow flange plates by downhand welding. If downhand welding from both sides is attempted there is, in addition to the probability of some angular distortion at the joints when the weld is complete, the risk of cracking a partially completed weld when a long flange is being turned over by the crane. It is much safer, and probably just as economical, to make the flange joints in the vertical position with the plates standing on edge and with two welders, one on each side working simultaneously. The ends of the flange plates should be sawn or milled square to provide an accurate butt between the root faces at the joint. The U preparation would normally be done by chipping the plate edges, although some fabricating shops may equip themselves with special shaping machines which can deal economically with the ends of long, narrow plates.

It is important that the stiffeners should be sawn to exact lengths so that when tacked to the web they form a perfectly square bearing for the flange; discrepancies in lengths inevitably lead to fabrication difficulties and it is worth while taking a lot of trouble on this point. Once all the parts of the girder are firmly tack welded together, the general welding can proceed without any special restrictions except that the welds between web and flange should be roughly equalised as between top and bottom to avoid cambering the girder. If automatic welding is adopted the stiffeners may have to be added after welding the web to the flange is completed.

HYDRO-ELECTRIC FILM.—A film showing the construction of the Nechako–Kemano–Kitimat project in British Columbia has been made by the International Harvester Company, Ltd. The project involves a major hydro-electric scheme, linked with an aluminium smelter at Kitimat. The hydro-electric scheme was described in THE ENGINEER of May 29th and June 5th last. The film is in colour, and shows various aspects of the constructional work, and explains the layout of the hydro-electric scheme; it is entitled "Man with a Thousand Hands."

Industrial and Labour Notes

Engineering Wages

The token stoppage of work extending over twenty-four hours from Wednesday of last week affected output in the engineering and shipbuilding industries in many parts of the country. The stoppage was decided upon by the Confederation of Shipbuilding and Engineering Unions as a protest against the rejection of a claim for a 15 per cent increase in the wages of adult male workers. Various estimates have been made of the number of workers who participated last week in this twenty-four-hour strike ; it has been stated, for example, that the total exceeded 1,000,000.

On the following day, Thursday of last week, the national committee of the Amalgamated Engineering Union met to consider what further action concerning the wage dispute should be recommended to the Confederation of Shipbuilding and Engineering Unions. The main resolution, which was carried, was that the Confederation should recommend all the unions which were party to the claim to impose an embargo on overtime and piecework. It may be recalled that the claim for a 15 per cent increase in wages was originally suggested by the A.E.U. national committee, from which there also came, after the rejection of the claim, the suggestion of last Wednesday's token strike. As these notes go to press, the executive of the Confederation of Shipbuilding and Engineering Unions is meeting to discuss the dispute again, but it is not clear that it will, during the present meeting, consider the A.E.U. national committee's latest resolution.

Railway Wages

At the end of last week, the Railway Staff National Tribunal announced its award in the latest railway wage dispute. It recommended an increase of 4s. a week. Originally, a claim for a 15 per cent wage increase was presented to the Railway Executive by the three principal railwaymen's unions, the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen, and the Transport Salaried Staffs' Association.

The claim was rejected initially by the Railway Executive in September, and it was then considered by the Railway Staff National Council and again rejected by the Railway Executive's representatives on that body. The unions then asked that the Railway Staff National Tribunal should consider the claim. At the hearing last month, the union representatives argued that the claim was justified on account of the rise in living costs and because of the difference between railwaymen's wages and those paid in other industries. It was also asserted that railwaymen ought to share in the results of more efficient and economical working. Mr. W. P. Allen, who appeared before the Tribunal as the British Transport Commission's spokesman, said that to meet the 15 per cent claim would involve an addition of £31,000,000 a year to the railway wages bill. The railways' financial position was such, he explained, that the unions' claim could not be met either in whole or in part.

The three members of the Tribunal were Sir John Forster, independent chairman ; Sir Luke Fawcett, nominated by the unions, and Sir Percy Mills, who was nominated by the British Transport Commission. Their findings were that, " as from the commencement of the first pay week following December 3rd, the existing rates of pay of conciliation staff and railway salaried staff should be increased by 4s. a week for adult males, with proportionate increases for adult females, and juniors." The Transport Salaried Staffs' Association and the National Union of Railwaymen have expressed their dissatisfaction with the award, and yesterday a joint meeting of leaders of the three unions was held for a discussion of the matter. Meanwhile, the British Transport Commission has announced its decision to accept the award. It has stated that the cost of the additional wages and salaries of the section of the staff concerned will amount in a full year to £5,500,000.

Record Steel Production

The British steel industry achieved another production record in November, the average weekly output of ingots and castings being 363,000 tons. This represented an annual production rate of 18,878,000 tons, compared with a rate of 17,951,000 tons in November last year. Over the first eleven months of this year, steel production has been at an annual rate of 17,607,000 tons, against a rate of 16,087,000 tons in the corresponding period of 1952. Pig iron output in November was also at a record level, the average weekly production being 228,500 tons, which represented an annual rate of 11,883,000 tons.

Fuel and Power Statistics

The Ministry of Fuel and Power has now issued its *Statistical Digest of* 1952. It contains no less than 153 tables relating to the production and consumption of solid fuels, petroleum, electricity and gas in Great Britain, and also to the employment in the industries concerned. Some of the tables dealing with coal production include annual figures for the last 100 years. Three new tables show the number of establishments and the annual rate of consumption of solid and liquid fuel in each main industrial and non-industrial group. The digest is published by H.M. Stationery Office at £1 1s.

The latest statistical statement by the Ministry of Fuel and Power shows that, last week, coal output in Great Britain amounted to 4,801,800 tons. This total included 4,559,000 tons from the deep mines—the biggest weekly tonnage raised for several months—and 242,800 tons from opencast workings. In the first forty-eight weeks of this year, coal output has amounted to 207,069,500 tons, which is more than 2,000,000 tons below the total for the corresponding period of 1952.

Training for Ironfounding

The Council of Ironfoundry Associations has appointed a recruitment, training and education committee for the ironfounding industry. In making this announcement, the Council points out that the recruitment of new entrants to the industry has not been easy in recent years. It says that many boys and young men are unaware both of the opportunities for advancement which ironfounding offers and of the great and permanent importance of iron castings to the country's economy.

The Council's statement goes on to say that the steel industry itself is largely dependent on iron castings in the shape of ingot moulds. It also comments on the large tonnages of cast iron pipes needed for gas and water supplies, and upon the castings requirements of the motor vehicle manufacturing industry, the building industry and many branches of engineering. The Council feels that the work of spreading knowledge of the ironfounding industry among school-leavers, the training of new entrants and the further education of foundrymen should be placed upon a more systematic and effective basis, and that is the aim of the new committee. On the committee, eighteen associations of ironfounders are represented, as well as the British Cast Iron Research Association and the Institute of British Foundrymen.

Supervision of Iron and Steel Prices

In a written Parliamentary reply on Monday last, the Minister of Supply, Mr. Duncan Sandys, stated that the time had come for the Iron and Steel Board to take over full responsibility for supervising the prices of iron and steel products. The reply explained that under Section 8 of the Iron and Steel Act, 1953, the Iron and Steel Board was empowered to fix the maximum prices which might be charged in the United Kingdom by iron and steel producers. Section 10 of the Act, however, provided that the Board could not exercise those powers in respect of any product, the price of which was being controlled by the Government.

The reply therefore announced that, in order to put the Board in a position to exercise its responsibility for the supervision of prices, the Minister had made an order bringing all existing Iron and Steel Prices Orders to an end as from December 8th. The Iron and Steel Board had stated its intention forthwith to fix maximum prices covering approximately the same products as those controlled at present, and that for the time being, except in a few minor instances, no changes in the existing price schedules would be made. The Board's powers under the Act, the reply added, did not extend to the control of scrap prices. Consequently, the Iron and Steel Scrap Orders were not being revoked.

Industrial Welfare Society

The annual report of the Council of the Industrial Welfare Society, covering the year ended June 30, 1953, which was presented at the annual meeting on Wednesday, makes special mention of the increasing support given in all parts of the country to the meetings and training courses arranged by the Society. It states, for example, that during the year over 5900 delegates attended sixty-three one-day meetings and courses dealing with a variety of subjects. Courses lasting for longer than one day included those dealing with the technician and human relations in industry ; the training of foremen, and lifting and handling. Another course, which lasted a week and was arranged for junior executives, was devoted to a study of " Training for Management Succession."

The Director of the Society, Mr. John Marsh, expresses the opinion in the report that the year reviewed was a testing time for management-labour relations and welfare in industry. He says that the emphasis has been to a greater degree on productivity, which may perhaps be better described as " the need for more effective work from everyone." It would be true to say, Mr. Marsh comments, that there has been more awareness on the part of management and trade union officials during the last year or two of the need for greater productivity. But, his report adds, it is doubtful whether office and manual workers as a whole appreciate the need and how it is to be achieved. The report says that " there are as yet few successful schemes whereby workpeople are enabled to comprehend how their own better work can help the local, let alone the national, situation." The Industrial Welfare Society is convinced that only in an atmosphere of sound human relationships will there be any real chance to achieve such productivity as the country needs.

Dealing in rather more detail with some trends noted during the year, the Director comments that expenditure by industry and commerce on the training of all levels of management is growing at a remarkable rate. He says that a large number of companies, which hitherto have been hesitant, are now working out comprehensive and continuous training schemes. . There is, however, a great shortage of competent training officers and instructors. Another matter commented upon in the Director's report is apprenticeship. The report says there is much evidence to show that companies are slowly but surely modifying or modernising their apprenticeship schemes. The Industrial Welfare Society has always believed that the reception and use of young people in industry need to be improved, not only in attitude, but in techniques of training, if full justice is to be done to the individual apprentice and enough practical skilled men and technicians secured for industry's future needs.

Notes and Memoranda

Rail and Road

RAILWAY ACCIDENT REPORT.—The report has now been published of the inquiry made into the accident which occurred on May 24th last between Forest Gate and Manor Park on the Eastern Region of British Railways. In this accident a collision occurred at about 3.58 a.m. between an up freight train travelling slowly over the junction from the up electric line to the up main across the down electric line, and an electric passenger train on the down electric line. The electric train passed at danger the colour light signal protecting the crossover and struck the freight train. No lives were lost in the accident. The inspecting officer, as a result of his inquiry, concluded that the accident was caused by a lapse on the part of the driver of the electric train, who was not alert and had ceased to pay attention to the signals for a few critical moments.

Air and Water

T.S.S. "ARCADIA."—We are informed by the Peninsular and Oriental Steam Navigation Company that the company's liner "Arcadia," which was launched on May 14th from the yard of John Brown and Co. (Clydebank), Ltd., is expected to complete fitting out and go on trials in January next year.

LAUNCH OF H.M.S. "HARDY."—The anti-submarine frigate H.M.S. "Hardy" was launched from the yard of Yarrow and Co., Ltd., on November 25th. This ship, which revives the name of "Hardy" in the Navy, has an extreme length of 310ft by 33ft beam and is powered by geared steam turbines built by the shipbuilders to a design by the English Electric Company, Ltd.

INSTITUTION OF WATER ENGINEERS.—The Institution of Water Engineers held its fifty-eighth winter general meeting at the Institution of Civil Engineers on Friday last, December 4th. Following the usual formal business of the meeting, three papers were presented for discussion, namely, "Stratification and Overrun in Lakes and Reservoirs," by R. W. S. Thompson; "The Reduction with Age of the Carrying Capacity of Pipelines," by P. A. Lamont, and "The Construction of a Borehole in an Unconsolidated Formation Using a Graded Filter," by R. J. Bell.

TYNE TUNNEL.—On Monday last the Joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation, Mr. Hugh Molson, received a deputation from the Tyne Tunnel Joint Committee representing the Durham and Northumberland County Councils. The deputation stressed the urgency of the need for the completion of the Tyne tunnel scheme by the construction of the vehicular tunnel in order to ease the transport problems of heavy industry on both banks of the Tyne and to enable general road planning of the two counties to go ahead. Mr. Molson said that he was impressed by the case put by the deputation and agreed that the scheme was very necessary. He promised that it would be fitted into the future programme of road works as soon as could be managed.

WRIGHT BROTHERS JUBILEE EXHIBITION.—A special exhibition commemorating the fiftieth anniversary of the first successful flight by the Wright aeroplane in 1903 will open at the Science Museum, South Kensington, on Tuesday next, December 15th. It will include models, books, aeronautical relics and diagrams illustrating early contemporary thoughts and ideas on powered flight by a man-carrying machine; and how this was ultimately achieved by Wilbur and Orville Wright on December 17, 1903. A series of sixteen large, and in some cases dramatic, photographs will emphasise the many hazards faced by the early aeronautical pioneer. The exhibition will remain open for approximately three months. Admission is free, and the hours of opening will be weekdays, 10 a.m. to 6 p.m., and Sundays, 2.30 to 6 p.m.

Miscellanea

WORK STUDY COURSES.—A note announcing that Production-Engineering, Ltd., proposed to conduct training courses in work study and management was published in our issue of November 27th. In this note the wrong starting date was given for the first course, which will actually begin on January 18, 1954.

BRICK AND CEMENT OUTPUT.—At a recent meeting of the London and South-Eastern Regional Board for Industry, it was stated that more than 48,000,000 bricks were produced in the region during October. In the same month cement production totalled 411,483 tons and the output of plasterboard 3,087,620 square yards.

THE ASSOCIATION OF VERMICULITE EXFOLIATORS.—The Association of Vermiculite Exfoliators, Plantation House, London, E.C.3, has published a booklet describing the nature and uses of exfoliated vermiculite. Most of the uses mentioned relate to the building industry. A list of member firms of the Association is given in the booklet.

SOIL MECHANICS COURSE AT BIRMINGHAM.—We have received from Professor S. C. Redshaw, Department of Civil Engineering, the University, Edgbaston, Birmingham, 15, details of an evening course in soil mechanics which it is proposed to hold commencing on January 27, 1954. The course includes both lectures and laboratory experiments.

CONTROL SYSTEM FOR MOTOR-DRIVEN BLAST-FURNACE TURBO-BLOWERS.—In our issue of November 6th (pages 590–91), we described a control system for motor-driven blast-furnace turbo-blowers, in which use is made of "Askania" regulators. We should point out that the "Askania" regulators for this installation were made by Reavell and Co., Ltd., of Ipswich.

15MeV LINEAR ACCELERATOR FOR X-RAY THERAPY.—We learn from St. Bartholomew's Hospital, London, that a Philips 15 million-electron-volt linear accelerator for generating X-rays for deep therapy has been completed and is shortly to be installed. Initially it will be housed temporarily in a special building in the hospital's school in Charterhouse Square. When sufficient experience has been gained of the equipment and its capabilities, it will be transferred to a new building adjoining St. Bartholomew's Hospital, which will be its permanent home.

WELDING DESIGN COURSE.—The constructional design department of the Quasi-Arc Company, Ltd., has arranged another course on the design of welded structures. This course will commence on Tuesday, January 5, 1954, at the Institute of Marine Engineers, The Minories, London, E.C.3, and the lectures will be held on Tuesday and Thursday evenings, from 4.30 to 6 p.m., over a period of seven weeks. Details of the course and enrolment forms can be obtained on application to the constructional design department, The Quasi-Arc Company, Ltd., Bilston, Staffs.

TOOL COOLANT DEVELOPMENT.—Following a visit to the "Avon" production factory operated by Rolls-Royce, Ltd., at East Kilbride, we saw an application of the use of liquid carbon dioxide as a tool coolant which we stated in THE ENGINEER, November 27th, to have been developed by the company. We learn, however, that the method and the apparatus used were in fact developed by the Carbon Dioxide Company, Ltd., in association with the Central Research Department (Engineering Section) of the Distillers Company, Ltd. The Distillers Company, Ltd., hopes to be able shortly to publish details of this development.

PROTECTION OF METALS BY PAINTS.—The Battersea Polytechnic, London, S.W.11, announces a series of eight lectures dealing with the protection of metals by painting. These lectures, which will be delivered on Thursday evenings, at 7 p.m., beginning on January 28th, are being arranged in conjunction with the corrosion group of the Society of Chemical Industry and the Oil and Colour Chemists' Association. The fee for the course is £1. The Battersea Polytechnic also announces an exhibition of protective methods for preventing the corrosion of steel, which will be held on Friday, January 21st, from 10 a.m. to 5 p.m.

EXPERIMENTAL INSTITUTE FOR MODELS AND STRUCTURES, ITALY.—The Experimental Institute for Models and Structures—"Ismes," as it is called—was formed in Northern Italy to undertake model studies on various structures, and in particular on various dams which were to be built in Italy to form reservoirs for hydro-electric schemes. The Institute has published an illustrated booklet, in the English language, which briefly outlines its organisation and the work it has so far carried out, and depicts model tests on a number of dams, including such well-known structures as the Pieve-di-Cadore dam. The Institute's laboratory is in the town of Bergamo, near Milan, its address being Viale Giulio Cesare 291, Bergamo.

ROYAL AGRICULTURAL SOCIETY.—At the annual meeting of the Royal Agricultural Society of England, which was held in London on December 2nd, it was stated that the accounts for the 1952 Royal Show at Newton Abbot showed a deficit of £12,000. Most of the livestock section had to be cancelled, owing to foot-and-mouth disease, shortly before the opening of the show. The revenue from admission was £10,000 less than in the preceding year, while rent and reinstatement of the ground cost nearly £8000 more. At a council meeting of the Society, which was held on the same day, an invitation to hold the 1957 Royal Show at Norwich was accepted from the Royal Norfolk Agricultural Society. The site will be at Costessey, 4 miles from Norwich. The last time the Royal Show was held at Norwich was in 1911.

THE BRITISH INDUSTRIES FAIR.—In a statement to the House of Commons, Mr. Heathcoat Amory, Minister of State, Board of Trade, said that the Government had accepted the recommendation of the advisory committee that industry should take a greater direct interest in running the London section of the British Industries Fair, and that responsibility for it should be transferred to a new non-profit-making company. The board of the company would be persons nominated by trustees representative of industry, including, it was hoped, the Trades Union Congress and a Government nominee. The Government would guarantee the initial working capital for five years. The 1954 Fair would be run by the Board of Trade in the usual close collaboration with industry, and the 1955 Fair will be run by the new company. The Birmingham section of the Fair, it was stated, would continue to be run by the Birmingham Chamber of Commerce.

STEWARTS AND LLOYDS, LTD., GOLDEN JUBILEE.—The business of Stewarts and Lloyds, Ltd., was founded in 1903 by the amalgamation of two well-established firms in the tube making industry—A. and J. Stewart and Menzies, Ltd., of Glasgow, and Lloyd and Lloyd, Ltd., of Birmingham. To mark the occasion of the firm's fiftieth anniversary an interesting and entertaining book has been issued. This book gives first a brief background history of the two original firms and then an illustrated commentary on the major events within the organisation, and the national and international background against which they have taken place during the past fifty years. The tube making business of one of the parent firms, A. and J. Stewart and Menzies, Ltd., originated in a works opened in Glasgow in 1860 by Mr. Andrew Stewart. During the years which followed this business steadily expanded and merged with other firms, becoming successively A. and J. Stewart, Ltd., in 1882, A. and J. Stewart and Clydesdale, Ltd., in 1890, and finally A. and J. Stewart and Menzies, Ltd., in 1898. The firm of Lloyd and Lloyd, Ltd., was founded in 1859 by Mr. Samuel Lloyd and Mr. Edward Rigge Lloyd. The two firms were well established by the turn of the century when it was decided that it was to their mutual interest to join forces, and the amalgamation was completed in January, 1903. Since that time the story of the firm has been one of steady expansion, and the commemorative book traces in a most interesting way each major step in the growth of the company. The descriptive matter is profusely illustrated to show the activities of the firm and the wide field of application of its products in both peace and war.

SPHEROIDAL GRAPHITE CAST IRON.—A new publication dealing with the engineering properties of spheroidal graphite cast iron has been issued by the Mond Nickel Company, Ltd., Sunderland House, Curzon Street, London, W.1. The publication points out that the tensile strength of S.G. iron is about double that of a high-duty flake graphite iron, with a distinct yield point markedly higher than that of malleable cast iron. Its elongation is 1–5 per cent in the as-cast condition and 10–25 per cent in the annealed condition, and the elastic modulus, at 25,000,000 lb per square inch, approaches that of steel. This combination of properties shows that although S.G. iron has sufficient ductility to permit twisting and bending, it is nevertheless stiff and rigid and requires considerable force to cause permanent deformation. Although steel castings are superior to S.G. iron castings in ductility and shock-resistance, it is pointed out that there are many instances where the properties of S.G. iron are adequate and it can be used for intricate work which would be very difficult to produce in steel. The publication includes a list of typical applications and a bibliography and copies can be obtained free of charge from the company's offices.

Personal and Business

MR. J. E. T. WATSON has been appointed sales manager of F. E. Weatherill, Ltd., Union Row, London, N.17.

MR. M. E. O'KEEFFE TROWBRIDGE, A.C.G.I., has joined the staff of Sharples Centrifuges, Ltd., Stroud.

COMMANDER K. H. S. COHEN has been appointed European adviser to The United Steel Companies, Ltd., Sheffield.

CLARKSON (ENGINEERS), Ltd., states that it is building a two-bay extension to its factory at King Edward Road, Nuneaton.

MR. H. C. HARRISON, chief executive (engineering) of Flight Refuelling, Ltd., has been appointed a director of the company.

MR. C. J. RHODES has been appointed press officer of the National Union of Manufacturers, 8, Holborn Viaduct, London, E.C.1.

MR. PETER E. M. SHARP, A.C.G.I., has left Telegraph Construction and Maintenance Company, Ltd., to join The China Engineers, Ltd., in Singapore.

MR. G. T. GEDGE has been appointed assistant general manager of Short Brothers and Harland, Ltd., Belfast. Mr. B. Penney has succeeded him as works manager.

MR. ERNEST TONKINSON has been appointed organising secretary of the Birmingham Productivity Association, with offices at the Chamber of Commerce, Birmingham.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that Mr. H. Williams has been appointed manager of the Worcester branch in succession to the late Mr. C. H. Panting.

F. E. WEATHERILL, Ltd., Union Row, London, N.17, has been appointed main distributor for Great Britain and overseas territories of the Epping auto-shunter manufactured by Epping Engineers, Ltd.

MR. N. C. ROBERTSON has resumed his duties as deputy managing director of E. K. Cole, Ltd., following two years' voluntary service as Director-General of Electronics Production in the Ministry of Supply.

THE ENGLISH ELECTRIC COMPANY, Ltd., announces that Mr. H. G. Nelson, M.A., its deputy managing director, who is also a director of Marconi's Wireless Telegraph Company, Ltd., has been asked to join the board of the Canadian Marconi Company.

COVENTRY CLIMAX ENGINES, Ltd., has appointed Mr. G. W. Baker as resident fork truck sales engineer for Yorkshire, Durham and Northumberland. His address is 109, Redesdale Gardens, Adel, Leeds, 6 (telephone, Leeds 73829). Mr. J. Twiggins has joined the company's fork truck technical sales department at Widdrington Road Works, Coventry.

Q.V.F., Ltd., is a new company formed to market the "Visible Flow" glass pipeline manufactured by James A. Jobling and Co., Ltd., and the "Quickfit" industrial plant of Quickfit and Quartz Ltd. Sir Graham Cunningham is chairman of the new company and Mr. Brian H. Turpin is the managing director. The headquarters of the new company are at Mill Street, Stone, Staffs.

EVERSHED AND VIGNOLES, Ltd., Acton Lane Works, Chiswick, W.4, has taken over the distribution of the products manufactured and previously marketed by Tinsley (Industrial Instruments), Ltd. Mr. W. A. Shaw has been appointed sales director and a member of the board of Evershed and Vignoles, Ltd., and Mr. H. W. Griffiths has succeeded him as general sales manager.

British Patent Specifications

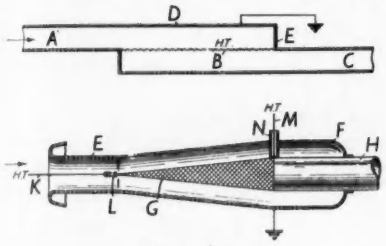
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application: the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

FILTERS AND SIEVES

698,874. February 9, 1950.—ELECTROSTATIC GAS CLEANERS, Power Jets (Research and Development), Ltd., 25, Green Street, London, W.1. (*Inventor: Ivor Macaulay Davidson.*)

The invention relates to electrostatic apparatus for cleaning air or other gaseous fluids by removing particles having a mean diameter of 20 microns or less. One object of the invention is to provide an electrostatic precipitator which will be capable of being designed to deal with flows of very high velocity without incurring undue pressure loss and avoid the possibility of a "blow through." As shown in the upper drawing, the gas enters the apparatus through an inflow duct *A*, passes through a porous partition *B* in the wall of the duct and leaves through an outflow duct *C* adjoining the inflow duct. The partition *B* is maintained at a high potential, and the side *D* facing the partition is earthed, while the blind end *E* is of insulating material. The screen has a large gas passage area compared with the cross section of the ducts. Particles in the inflow air, if not already charged, are given a charge of the same polarity as the potential on the porous partition. The lower drawing represents a practical embodiment of the invention suitable for dealing with fairly small ventilation airflows. Air to be cleaned enters through



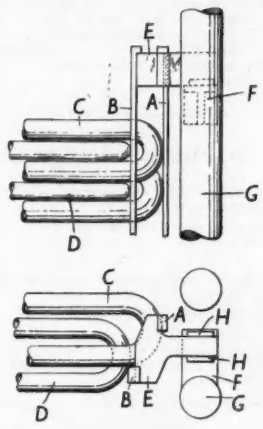
No. 698,874

a duct *E* which is initially parallel and then diverges and ends in a blind passage *F*. A porous screen *G* in the form of a cone is mounted within and co-axially with this duct, so that it is parallel to the divergent part of the duct *E*, and the base of this screen is connected to an outlet duct *H*. The divergence of the duct *E* is such that the surface area of the conical screen is large compared with the cross section areas of the inflow and outflow ducts, and consequently the air velocity normal to the screen is much reduced compared with the inflow and outflow velocities to the apparatus. A wire *K*, connected to a high-tension source, passes down the middle of the inlet duct and is attached to the apex of the conical screen through an insulator *L*. The screen is itself connected to a high-tension power supply by a wire *M* passing through the side of the duct in insulating tube *N* and is thus maintained at a high potential. The particles in the inflow air become charged by electric discharge between the wire *K* and the duct *E*, and on entering into the space between the screen and the divergent part of the duct experience a force normal thereto. As before, particle velocity in this direction is comparatively low and hence the field strength is sufficient to repel them to the outer wall, thus preventing them from passing through the screen. Alternative air cleaners for larger outputs are also shown in the specification.—*October* 28, 1953.

HEAT EXCHANGERS

699,581. October 31, 1950.—TUBULAR HEAT EXCHANGERS, E. Green and Son, Ltd., Economiser Works, Wakefield, Yorkshire. (*Inventor: Cyril Wright Parris.*)

According to the invention means are provided in a tubular heat exchanger for limiting the relative movement between the coils. Flexible bars are secured in a vertical position to the outer face of the bends of each coil at each end, and are movably supported. As shown in the upper drawing, flexible bars *A* and *B* are welded in a vertical position to the outer face of the bends *C* and *D* of each coil. There are thus two vertical bars at each end of the completed element, one attached to the outer coil *C* and one attached to the inner interdigitated coil *D*. These bars *A* and *B* are attached to a suspension block *E* at each end, the distance between the suspension block and the uppermost tube coils being such as to allow flexure of the vertical bars when relative movements due to expansion or contraction take place between the outer and inner coils. The suspension blocks rest upon angle brackets *F* welded to the vertical tubes *G* or other vertical supports. Guide strips *H* may be formed or secured on the top faces of the angle brackets to limit the sideways movement while permitting free endwise movement. In this way the tube coils *E* and *D* are suspended from the angle brackets *F* with free endwise



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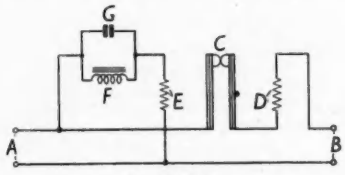
movement, and the coils themselves are able to move with respect to each other, and the vertical generating tubes *G* provide cooling for the supporting arrangements. In a further drawing (not reproduced), the vertical stepped bars to limit movement and not to take weight, which are as described in the specification No. 679,058, are shown.—*November* 11, 1953.

ELECTRICAL ENGINEERING

695,816. October 30, 1950.—LIMITATION OF PEAK LOAD IN ELECTRIC SUPPLY SYSTEMS, National Research Development Corporation, 1, Tilney Street, London, W.1. (*Inventor: Reginald George Voysey.*)

The invention relates to the limitation of the peak load in an alternating current supply feeding a number of consumer circuits. The drawing shows a circuit diagram illustrating one form of regulator in accordance with the invention. The input terminals are indicated at *A* and the output terminals at *B*. *C* is a bi-metal switch operated by the low resistance heater winding *D* and the high resistance heater winding *E*. The frequency selective network comprises the choke *F* and condenser *G* forming a parallel tuned circuit which, with the resistance *E* in series therewith is con-



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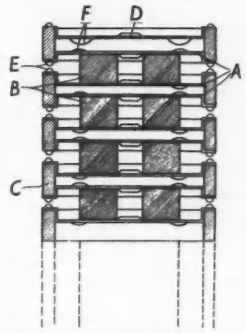
nected across the input of the regulator. Approximate values of the components for a 2kW load are as follows:—*D*=0·01 to 0·05 ohms, depending upon the maximum load permitted; *E*=1900 ohms; *G*=6 microfarads; *F*=of the order of 1 Henry. With the arrangement described, if the consumer exceeds the controlled load permitted by the regulator, the thermostatic switch will function to turn his supply on and off in regular sequence until he voluntarily reduces his connected load to the point where it is within the characteristic of the device. He gains by so doing because, owing to the hysteresis of the switch, the average of an excessive load drawn intermittently will be less than the lower load which can be continuously drawn. In the specification there is shown a modified arrangement of the contact strips together with examples of the adjustment of the device for various duties.—*August* 19, 1953.

698,352. January 26, 1951.—ELECTRIC SURGE DIVERTER ARRANGEMENTS, The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2; and Horace Frederick Jones, of The General Electric Company, Ltd., Engineering Works, Witton, Birmingham.

The invention relates to electric surge diverter arrangements comprising a number of spark gaps connected in series with one or more non-linear resistive elements. Referring to the drawing, a surge diverter is built up in the form of a stack of identical metal electrodes *A*, non-linear resistive elements *B* and equalising impedances *C* in the form of linear or non-linear resistances. In the arrangement shown the non-linear resistive elements are in the form of annular blocks while the equalising impedances are in the form of annuli of rather larger internal diameter than the external diameter of the non-linear resistive elements. The metal electrodes which are all identical consist of dished and flanged plates. Each metal electrode is formed with a central boss *D*, which locates the non-linear resistive element. At points around the flanged portion each metal electrode is provided with part-spherical protruberances *E*, which co-operate with similar protruberances on the adjoining metal electrode *A* when the assembly is completed so as to form a secondary spark gap which is arranged in parallel with a non-linear resistive element *B*. Part-spherical protuberances *F* are also formed on the dished portion of each metal electrode *A*, which co-operate with similar protuberances on an



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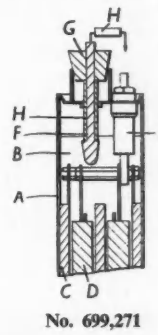
adjoining electrode so as to form a spark gap arranged in parallel with one of the equalising impedance elements *C*. By the use of an assembly of this type the overall length of the stack of electrodes, non-linear resistive elements and equalising impedance elements can be made considerably shorter than would be the case if they were placed end to end. Moreover, the dished arrangement of the metal electrodes facilitates the provision of spark gaps in parallel with the non-linear resistive elements *B* and the equalising impedance elements *C* as appropriate portions of the metal electrodes are brought closer together than the axial length of the non-linear resistance elements or the equalising impedance elements. Metal electrodes of this form can readily be produced as stampings from sheet metal blanks. Alternative designs are also mentioned in the specification.—*October* 14, 1953.

699,271. June 22, 1951.—ELECTRIC STORAGE BATTERIES, The Mond Nickel Company, Ltd., Sunderland House, Curzon Street, London, W.1. (*Inventors: Harold William George Hignett and Paul Hersch.*)

The invention relates to electric storage batteries having an alkaline electrolyte and a negative plate formed of finely divided iron, which on normal discharge becomes oxidised. An electric storage battery constructed in accordance with the invention has a steel case *A* with insulating bushes in its top, through which the connections emerge. The case contains a strong aqueous solution of potassium hydroxide *B*, in which are immersed negative plates *C* in the form of cages containing finely divided iron and positive plates *D* in the form of a series of tubes containing finely divided nickel. The plates in each set are connected together and to a terminal by a cross bar. In the drawing the negative terminal is concealed by the positive terminal *E*. An auxiliary electrode *F* of zinc with its surface amalgamated with mercury is inserted through a bung *G* so that its tip is immersed in the electrolyte. At the level of the surface of the electrolyte the auxiliary electrode is protected by an insulating sleeve *H*. The auxiliary electrode is connected by a resistance *L* to the negative terminal of the battery. The bung can be removed to permit renewal of the auxiliary electrode and also to permit topping up of the electrolyte.—*November* 4, 1953.



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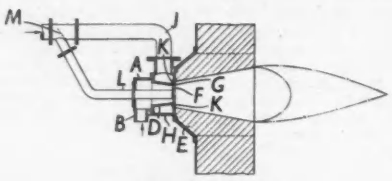
BURNERS AND SPRAYERS

699,705. June 5, 1951.—BURNERS FOR GASEOUS FUEL, The Wellman Smith Owen Engineering Corporation, Ltd., Parnell House, 25, Wilton Road, London, S.W.1. (*Inventor: James Wilson Reber.*)

As will be seen from the drawing, the burner comprises a body *A* of cylindrical form with an open inner end and a closed outer end. The body is con-

nected to a gas supply pipe *B*. A main tubular part *D* is mounted at the open end of the body and at its forward end is fixed to the wall of a burner block *E* of a furnace. The tubular part *D* decreases slightly in diameter from its end connected to the body to an outlet point *F*, close to the burner block *E*, from which point it increases rapidly in diameter to the wall of the burner block to provide an inclined



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wall *G*. The tubular part *D* is surrounded by a casing *H* which is connected at one end to the body and at the other end to the wall of the burner block. The annular space between the casing *H* and the tubular part *D* is connected to a combustion air supply pipe *J*. The inclined wall *G* constitutes part of the end closure of this annular space and is apertured at *K* to provide a number of outlets for air directed inwards at an angle to the gas stream leaving the outlet *F*. In use the combustion air and gas become intimately mixed within the burner block *E* and a short hot flame is produced. For annealing furnaces, high combustion temperatures are not always required and it would be advantageous to produce a longer flame at a lower mean temperature. It has now been found that this can be achieved by supplying part of the combustion air normally passing to the outlets *K* through a separate pipe *L* placed in the gas stream to provide a parallel flow of gas and air. This pipe is connected to the combustion air supply pipe *J* through a regulating valve *M* which controls the proportion of air supplied. The valve, which may be of the paddle type, is capable of operation to a position in which it completely cuts off the supply of air to the additional tubular part.—*November* 11, 1953.

Technical Reports

Discharges in Dielectrics at High Voltages and in the Presence of Harmonics (Ref. L/T271). By J. H. Mason. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 12s., postage 4d.—The variation of the discharge sequence in insulation with applied alternating voltage has been investigated up to four times the inception voltage, with and without a superposed tenth harmonic, and with unidirectional voltage pulses. At voltages exceeding twice the inception value the discharge sequence in voids enclosed in polythene differs from that predicted by Austen and Whitehead. In particular, discharges in the quadrants of falling voltage begin much later than expected. The discharge sequence can be interpreted if the interdependence of adjacent discharge sites is considered and if the first discharge occurs at a lower stress in the void than any subsequent discharge. If the void is adjacent to a conductor the effect of residual surface charges is reduced, and the discharge sequence is similar to that predicted by Austen and Whitehead. The superposition of a harmonic increases the number of discharges appreciably only if the harmonic voltage exceeds the inception voltage. When unidirectional pulses are applied continuous discharges occur only if the pulse voltage exceeds approximately twice the inception voltage.

Measurement of Radio Interference in the Frequency Range 0·15 *Mc/s to* 30 *Mc/s. A Portable Measuring Set* (Ref. M/T116). By S. F. Pearce and D. C. G. Smith. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 10s. 6d., postage 3d.—The performance and characteristics of equipment for the measurement of radio interference in the frequency range 0·15 Mc/s to 30 Mc/s are prescribed in the latest revision of B.S.727. This standard is intended primarily for equipment to be used for measurements in relation to interference with the reception of broadcasting in this country. Except that the signal-to-noise ratios for satisfactory reception are not the same and that the bandwidth of military equipment is generally narrower than that used for the reception of broadcast programmes, the problem of interference with military communications differs little from that envisaged in the above standard. Accordingly the equipment described, which has been developed under contract to the Admiralty, has been designed to conform, in essential matters, with the standard.

Despite the severe restrictions on bulk, it has been possible to produce a receiver conforming to B.S. 727 in all respects except the requirements for image frequency rejection and intermediate frequency rejection.

Launches and Trial Trips

HADRA, oil tanker, built by Smith's Dock Company, Ltd., for the Anglo-Saxon Petroleum Company, Ltd.; length between perpendiculars 530ft, breadth moulded 69ft 3in, depth moulded 39ft, deadweight 18,000 tons, service speed 14·5 knots; thirty-three cargo oil tanks, one pump room, four 400 tons per hour cargo oil pumps, two 550kW turbo-alternators, one 200kW diesel-driven generator; machinery built by R. and W. Hawthorn Leslie and Co., Ltd., one set of double-reduction geared turbines, two Foster Wheeler "D" boilers supply steam at 500 lb per square inch and 800 deg. Fah. Launch, November 20th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Tues., Dec. 15*th.*—W. MIDLANDS SECTION: Technical College, Wulfruna Street, Wolverhampton, "Printed Circuits: Some General Principles and Applications of the Foil Technique," P. Eisler, 7.15 p.m.

DIESEL ENGINE USERS ASSOCIATION

Thurs., Dec. 17*th.*—GENERAL MEETING: Caxton Hall, Westminster, London, S.W.1, Discussion on "Working Costs Report," 2.30 p.m.

INCORPORATED PLANT ENGINEERS

Mon., Dec. 14*th.*—DUNDEE BRANCH: Mathers Hotel, Dundee, Talk by a Metallurgist, 7.30 p.m.
Tues., Dec. 15*th.*—S. WALES BRANCH: Mackworth Hotel, Swansea, Ten Minute Technical Talks by Members, followed by Discussion, 7.30 p.m.
Wed., Dec. 16*th.*—GLASGOW BRANCH: Scottish Building Centre, 425/427, Sauchiehall Street, Glasgow, "Application of Fuel Oils," Peter Wilson, 7 p.m.
Thurs., Dec. 17*th.*—BLACKBURN BRANCH: Grosvenor Hotel, Lord Street, Blackburn, "Hydraulics in Industry," 7.30 p.m.
Fri., Dec. 18*th.*—BIRMINGHAM BRANCH: Imperial Hotel, Birmingham, "Industrial Safety," E. E. Jellife, 7.30 p.m.

INSTITUTE OF FUEL

Tues., Dec. 22*nd.*—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, "The Festival Hall Heat Pump," P. E. Montagnon, 5.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Dec. 14*th.*—JUNIOR LECTURE: 85, Minories, London, E.C.3, "Boilers," R. E. Zoller, 6.30 p.m.

INSTITUTE OF METALS

Mon., Dec. 14*th.*—SCOTTISH LOCAL SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Corrosion, Particularly Under Marine Conditions," P. T. Gilbert, 6.30 p.m.
Wed., Dec. 30*th.*—BIRMINGHAM LOCAL SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Metals in Telecommunications," C. E. Richards, 6.30 p.m.

INSTITUTE OF NAVIGATION

Fri., Dec. 18*th.*—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Developments in Radio Aids to Surface Navigation," 5 p.m.

INSTITUTE OF PETROLEUM

Wed., Dec. 16*th.*—STANLOW BRANCH: Grosvenor Hotel, Chester, "Manufacture and Applications of Grease," J. B. Matthews, 7.30 p.m.

INSTITUTE OF TRANSPORT

Mon., Dec. 14*th.*—Jarvis Hall, 66, Portland Place, London, W.1, "Road Transport and the Manufacturer," Henry Spurrier, 5.45 p.m.

INSTITUTE OF WELDING

Wed., Dec. 16*th.*—N. LONDON BRANCH: Manson House, Portland Place, W.1, "The Application of the Self-Adjusting Arc," P. T. Houldcroft, 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

To-day, Dec. 11*th.*—YORKSHIRE ASSOCIATION: Royal Station Hotel, York, "The Principles of Railway Signalling and Modern Trends," A. F. Wigram, 7 p.m.
Tues., Dec. 15*th.*—ORDINARY MEETING: Great George Street, Westminster, London, S.W.1, "Pimlico District Heating Undertaking of the City of Westminster," G. C. Carrothers, Bryan Donkin and A. E. Margolis, 5.30 p.m.
Wed. and Thurs., Dec. 16*th and* 17*th.*—Great George Street, Westminster, London, S.W.1, Conference on the North Sea Floods, Mornings 10 a.m. to 1 p.m., Afternoons 2 p.m. to 5 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Dec. 14*th.*—RADIO SECTION: Savoy Place, London, S.W.1, Discussion on "Will Transistors Oust Receiving Valves," opened by E. H. Cooke-Yarborough, 5.30 p.m.
Tues., Dec. 15*th.*—LONDON STUDENTS' SECTION: Savoy Place, London, W.C.2, "A High-Voltage Laboratory," R. E. James, 7 p.m.——S.E. SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, "Voltage Transformers and Current Transformers Associated with Switchgear," W. Gray and A. Wright, 7 p.m.
Wed., Dec. 16*th.*—SUPPLY SECTION: Savoy Place, London, W.C.2, "Some Design Features of the Semi-Outdoor Power Station at Ince," F. H. S. Brown, 5.30 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Mon., Dec. 14*th.*—WOLVERHAMPTON BRANCH: Compton Grange, Compton Road, Wolverhampton, "Radiography in Engineering," T. G. Smith, 7.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Dec. 15*th.*—39, Elmbank Crescent, Glasgow, "Some Factors in the Design and Lubrication of Journal Bearings," A. S. T. Thomson, A. W. Scott, W. Ferguson and H. L. McBroom, 6.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Dec. 16*th.*—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, "Some Questions About the Steam Locomotive," W. A. Tuplin, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Dec. 11*th.*—GENERAL MEETING: Storey's Gate, St. James's Park, London, S.W.1, "Practical Training in Industry for the Graduate in Mechanical Engineering," K. R. Evans, H. W. Fulton, R. S. Medlock, D. P. Lant and J. A. Pope, 5.30 p.m.
Wed., Dec. 16*th.*—SOUTHERN BRANCH: R.A.E. Technical College, Farnborough, Hants, "Contemporary Methods of Watch Production," R. A. Fell, 7.30 p.m.——LUTON A.D. CENTRE: Town Hall, Luton, "The Manufacture and Properties of Automobile Suspension Springs," C. J. Dadswell, J. E. Russell and R. Fielding, 7.30 p.m.
Thurs., Dec. 17*th.*—MIDLAND BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, Annual General Meeting, 6 p.m.——AUTOMOBILE DIVISION, STEAM GROUP DISCUSSION: Storey's Gate, St. James's Park, London, S.W.1, "The Rapid Shutting Down of Large Generating Plant Under Fault Conditions," 6.45 p.m.
Fri., Dec. 18*th.*—GENERAL MEETING: Storey's Gate, St. James's Park, London, S.W.1, "The New British Standard System of Limits and Fits," H. G. Conway; "The Practical Application of the New British Standard System of Limits and Fits," G. J. Pearmain, 5.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

To-day, Dec. 11*th.*—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Maintenance of T.V. Links," C. E. E. Clinch and L. Thomas, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Dec. 11*th.*—W. WALES SECTION: Central Public Library, Alexandra Road, Swansea, "Leadership," K. C. Appleyard, 7 p.m.
Mon., Dec. 14*th.*—DERBY SECTION: Midland Hotel, Midland Road, Derby, "Effective Utilisation of Materials," F. Nixon, 7 p.m.——MANCHESTER SECTION: Reynolds Hall, College of Technology, Sackville Street, Manchester, 1, "Control of Size in the Engineering Industry," J. Loxham, 7.15 p.m.——OXFORD SECTION: Randolph Hotel, Beaumont Street, Oxford, "The Design and Manufacture of Refrigerators on Mass Production Lines," A. O. B. Brandon, 7.15 p.m.——SHEFFIELD SECTION: Grand Hotel, Sheffield, "Heavy Armoured Vehicle Fabrication," J. W. Brind, 6.30 p.m.——YORKSHIRE SECTION: Great Northern Hotel, Leeds, "Cutting Tool Research," G. V. Stabler, 7 p.m.
Tues., Dec. 15*th.*—LONDON GRADUATE SECTION: 36, Portman Square, W.1, "Modern Cutting Fluids," H. E. Priston and W. J. S. Hunter, 7.15 p.m.
Wed., Dec. 16*th.*—BIRMINGHAM SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, 3, "Developments in Metal Forging," H. Orford, 7 p.m.——CORNWALL SECTION: Technical College, Trevensen Park, Pool, Redruth, "Recent Developments in the Economic Use of Materials," M. P. H. A. Levie, 7.15 p.m.
Thurs., Dec. 17*th.*—GLASGOW SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Maintenance and the Production Engineer," A. J. Macintyre, 7.30 p.m.——SOUTHERN SECTION: Polygon Hotel, Southampton, "High-Speed Press Work," J. A. Grainger, 7.15 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Thurs., Dec. 17*th.*—11, Upper Belgrave Street, London, S.W.1, "Some Structural Uses of Aluminium Alloy with special reference to Domes," W. Hamilton and G. P. Manning, 5.55 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Dec. 11*th.*—Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, Presidential Address, "Developments and Future Possibilities in Electricity Generation," Sir John Hacking, 7.30 p.m.
Mon., Dec. 14*th.*—SHEFFIELD AND DISTRICT SECTION: Livesey Clegg House, Sheffield, "Some Aspects of Railway Electrification," W. D. Sheers, 7.30 p.m.
Tues., Dec. 15*th.*—Babcock and Wilcox, Ltd., Salisbury Square House, Salisbury Square, London, E.C.4, Film, "Steam Power," 6.30 p.m.

NEWCOMEN SOCIETY

Wed., Dec. 16*th.*—Science Museum, South Kensington, London, S.W.7, "The Engineers of the English River Navigations, 1620–1760," A. W. Skempton, 5.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Dec. 11*th.*—Mining Institute, Newcastle upon Tyne, "Vibration Tests on an Up-River Collier with special reference to the Influence of Depth of Water," A. I. Johnson and W. J. Marwood, 6.15 p.m.

OLD CENTRALIANS

Mon., Dec. 14*th.*—Chez Auguste Restaurant, 47, Frith Street, London, W.1, "International Cargo Handling," Rear-Admiral Mark-Wardlaw, 12.45 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Dec. 15*th.*—SECTION LECTURE: 4, Hamilton Place, London, W.1, "Jet-Driven High-Speed Wind Tunnels," D. L. Ellis, 7 p.m.

ROYAL SOCIETY OF ARTS

Wed., Dec. 16*th.*—John Adam Street, Adelphi, London, W.C.2, "The Work of the Wright Brothers for Aviation," J. Laurence Pritchard, 2.30 p.m.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS

Mon., Dec. 14*th.*—The University Building, St. George's Square, Sheffield, Annual General Meeting, "Some Notes on Design and Development of the Deltic Lightweight Diesel Engine," E. Chatterton, 7.30 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Tues., Dec. 15*th.*—Geological Society, Burlington House, Piccadilly, London, W.1, "Instruments for Quality Control," G. C. Eltenton, 5.30 p.m.

SOCIETY OF ENGINEERS

Mon., Dec. 14*th.*—17, Victoria Street, London, S.W.1, Annual General Meeting, 5.30 p.m.
Thurs., Dec. 17*th.*—INFORMAL MEETING: 17, Victoria Street, London, S.W.1, Annual General Meeting and Ten-Minute Papers, 6 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., Dec. 15*th.*—CONTROL SECTION: Manson House, Portland Place, London, W.1, "Sectional Paper Machine Drives with Electronic Control," T. E. Barany, 7 p.m.